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# CARCINOMA OF THE COLON AND RECTUM*

## DEDUCTIONS FROM EIGHT HUNDRED OPERATIONS

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THE title of this paper was chosen in order that I might not be limited in it to the discussion of any one aspect of this disease, but rather so that I would be able to present deductions from our experiences with various aspects of the subject which might be of value to others who have perhaps not had the opportunity of dealing with these patients in such numbers.

While everyone who is dealing with patients who have carcinomata of the colon and rectum is very conscious of their frequent origin in polypi and adenomata which are, on their first appearance, benign, altogether too little has been written and said concerning the relationship of polypi and adenomata of the large intestine to cancer. Those of us who are interested in this subject have preached and written on the need for earlier diagnosis of carcinoma of the large bowel, the relatively low grade of malignancy which these lesions show, and the high percentage of cures which can be obtained by radical surgical measures. We need, however, to call attention forcibly to the fact that since most cancers of the rectum and colon originate in lesions which are primarily benign and removable in their benign stage, the most important teaching which can be spread before the public, medical and lay, is the need for the diagnosis and removal of polypi and adenomata before they become malignant.

When one realizes that 75 per cent of all the carcinomata occurring in the large bowel arise in the descending colon, sigmoid, rectosigmoid and rectum, that the statistics of Mr. J. H. Saint show that 65 per cent of all the polypi occurring in the large bowel arise in the descending colon, sigmoid, rectosigmoid and rectum, one cannot avoid making the deduction that there is a distinct association between the two. One cannot avoid making comparison of the origin of carcinoma of the thyroid in adenomata which are primarily benign with the origin of cancer of the rectum in papillomata and adenomata which are likewise primarily benign, the removal of which, in both instances, while still benign is the desirable stage in which to attack potential carcinoma of the large bowel or potential carcinoma of the thyroid.

When one realizes that most of the pathologic reports of specimens of carcinoma of the colon and rectum are either malignant adenoma or adeno-

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carcinoma, one likewise cannot avoid making a deduction of a possible association between this lesion and polypi and adenomata.

When one visualizes typical lesions found in carcinoma of the colon and rectum spreading from a central point to a periphery with elevated edges, one cannot likewise again avoid making the deduction that such a carcinoma started in a lesion at a central point which was originally benign, only to become malignant and spread peripherally.

When one further realizes the quite well established clinical maxim, that when a malignant lesion of the large bowel completely encircles the entire caliber of that structure it is from six months to one year old, one cannot avoid making the deduction that this lesion in the beginning started at a local point, probably from a polyp or adenoma, only to spread out peripherally and involve the entire lumen of the bowel.

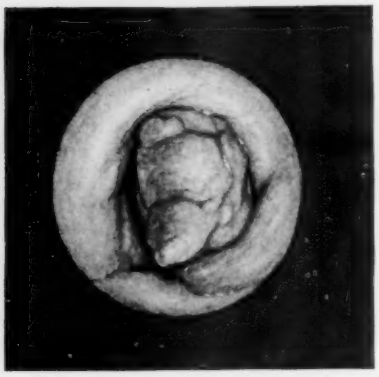

FIG. 1.—A rectal polyp seen through a proctoscope. This is an ideal polyp for fulguration, and one can readily appreciate from this lesion how carcinoma may originate in it.

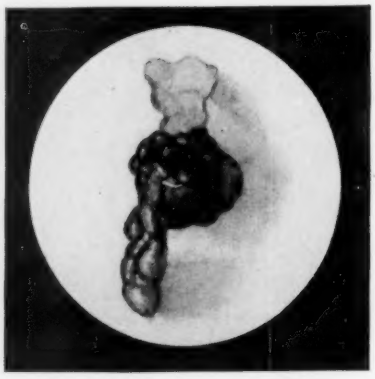

FIG. 2.—Polyp removed from the sigmoid by sigmoidotomy. This occurred in a doctor in whom there was a history of blood in the stools for a period of two years, the cause never having been discovered. This was, however, finally demonstrated by contrast enemata.

Pathologically, it proved benign. Note the generous area of mucosal base removed.

All of the above deductions lead one to the conclusion that we must all be more diligent and painstaking in our search for polypi and adenomata in the presence of the passage of any blood by rectum.

While thorough proctoscopic, sigmoidoscopic and contrast barium enema examinations must be undertaken in the colons and rectums of all patients passing blood, there is an even greater necessity that routine proctoscopic and sigmoidoscopic examinations be made on all patients presenting themselves for physical examination for any condition whatsoever, no matter how unrelated it may be to a possible colon or rectal lesion. This is necessary, if we are to discover the largest possible number of polypi and adenomata before they have become malignant in character or very early in their stage of malignant degeneration, since many of these polypi and adenomata exist without the appearance of blood in the stools until they have become malignant in character. As evidence of the value of this routine procedure, it is of interest to state that with routine proctoscopic examinations made in the clinic,

only within the last two to three years, polypi and adenomata have been found and removed either by fulguration through the sigmoidoscope or proctoscope or by sigmoidotomy or colotomy in 250 patients. One cannot, of course, say that every one of these patients would have had a cancer of the rectum or colon, but again one cannot avoid making the deduction that by the removal of these adenomata, while still benign, a number of these patients have been saved from the later development of carcinoma of the rectum or colon.

The proper preparation of patients for sigmoidoscopy, by means of cleansing enemata and the proper tables for obtaining satisfactory position for proctoscopy and sigmoidoscopy, hardly requires mention. It is, however, of great importance to call attention to the greater satisfaction with which such examinations can be made with the patient hanging over the edge of the proper table so that the rectum hangs by its levator and anal attachments. When proctoscopic and sigmoidoscopic examinations are made in this position, liquid feces do not run into the examining instrument to occlude vision, and the walls of the suspended rectum and sigmoid adjust themselves readily to visualization of polypi, adenomata and malignancies arising in them.

As the result of our experience in fulgurating these polypi and adenomata, we would particularly call attention to the dangers associated with fulguration of high polypi and adenomata and the need of undertaking fulguration in such high lesions with the patient in the hospital where emergencies, should they arise, can be immediately dealt with. One can never be sure, in fulgurating polypi and adenomata high in the rectum and sigmoid, that uncontrollable bleeding will not occur. Should such a situation arise in a patient fulgurated in one's office, valuable time and unnecessary blood is lost in transporting such an individual to a hospital for a necessary abdominal procedure to control such bleeding.

One does not need to discuss before this audience the value of contrast enemata in demonstrating large bowel adenomata and polypi while still in the benign stage and safely removable by colotomy. Roentgenologists should not forget the necessity of thoroughly cleansing the entire colon if one wishes to obtain good outline patterns of the mucosal lining of the colon. One cannot expect thin barium mixtures to adhere to the mucosal wall of the colon when that structure is filled with feces.

We are so constantly urged, both by patients and their family physicians, to perform local, nonmutilating operations by which the sphincter is preserved when the lesions are very small, that one of the important deductions which has resulted from this experience should be forcibly stated; that is, that in general, the smaller the lesion, if definitely proven to be malignant, the more aggressive should be the surgery, as the better is the chance for a permanent cure. One is a poor adviser if one permits himself to be persuaded by unwise patients and an uninformed family physician into performing a local operation on a small malignant lesion only to have the patient return for a radical operation in a state when the possibility of a cure is hopeless.

Dr. Neil W. Swinton has reviewed 100 proven cases of carcinoma of the

right colon, 100 proven cases of carcinoma of the left colon and 100 proven cases of carcinoma of the rectum, relative to their symptomatology (Table I).

TABLE I

ANALYSIS OF 300 CASES OF PROVEN CARCINOMATA OF THE LARGE BOWEL AT DIFFERENT LEVELS, RELATIVE TO THEIR SYMPTOMATOLOGY

| | Rectum | Left Colon | Right Colon | Total |
|---|---|---|---|---|
| | 100 | 100 | 100 | 300 |
| | | Per Cent | | |
| 1. Altered bowel function | 79 | 82 | 81 | 80 |
| 2. Abdominal cramps or pain | 7 | 77 | 87 | 57 |
| 3. Abnormal stools | 86 | 47 | 9 | 46 |
| 4. None | 2 | 2 | 3 | 2.3 |

When one realizes that out of these 300 cases of proven carcinoma of the large bowel at different levels, 97.5 per cent had an alteration in some form of bowel function, one wonders how it is possible to miss the diagnosis in these cases.

While alteration of bowel function as an indication of the presence of a possible malignancy of the colon has been repeatedly preached and written about, there is still a lamentable lack of appreciation in the minds of lay people and many physicians that an alert awareness of the significance of this symptom as an indication for thorough colonic and rectal examinations would bring about many more earlier diagnoses than are now made. This alteration consists of constipation, diarrhea, alternating constipation and diarrhea, passage of blood or a change in the caliber of the stool. The presence of any one of these alterations in bowel function should make proctoscopic and sigmoidoscopic examinations, adequate rectal examinations and colonic investigation by contrast enemata obligatory.

Perhaps there has been nothing which has been more encouraging to everyone who is dealing with these lesions than the progressive increase in operability of these patients with carcinoma of the large bowel, as they present themselves for examination in the later years. Up to three years ago, our operability in terms of radical removal of the lesion was 69 per cent. Up to one year ago this had increased to 72 per cent, and during the last year the operability increased to 88 per cent. When 88 per cent of the patients presenting themselves for the question of surgery can be submitted to radical procedures, some explanation, of course, becomes necessary, and such a high operability rate cannot be expected in everyone's hands. This high rate is explained, we believe, (1) by the fact that many early carcinomata are discovered by the members of the gastro-enterologic and proctologic departments of the clinic while making routine examinations; (2) by the fact that many of the patients upon whom we operate are sent to us for operations because of our interest in this subject and so are within the operable stage; and finally (3) by the fact that with widening experiences with the operation many carcinomata of the colon and rectum are removed even when moderate-sized metastatic nodules are present in the liver. The position that the radical

removal of the growth either in the colon or rectum should be undertaken, even in the presence of small metastases in the liver, has been quite universally accepted by all who are dealing with these cases in any considerable number. It is now quite generally accepted that the death from distant metastases is not only delayed by the removal of the local growth, but is much less distressing than that associated with the local extension of the growth left in place.

From the point of view of the percentage of cases in which various types of operations are performed, it will be of interest to state that 20 per cent are performed by the one-stage abdominosacral procedure, 65 per cent by the two-stage abdominosacral procedure which has been described, 11 per cent with the loop colostomy and a posterior resection, and 4 per cent by means of the anterior resection.

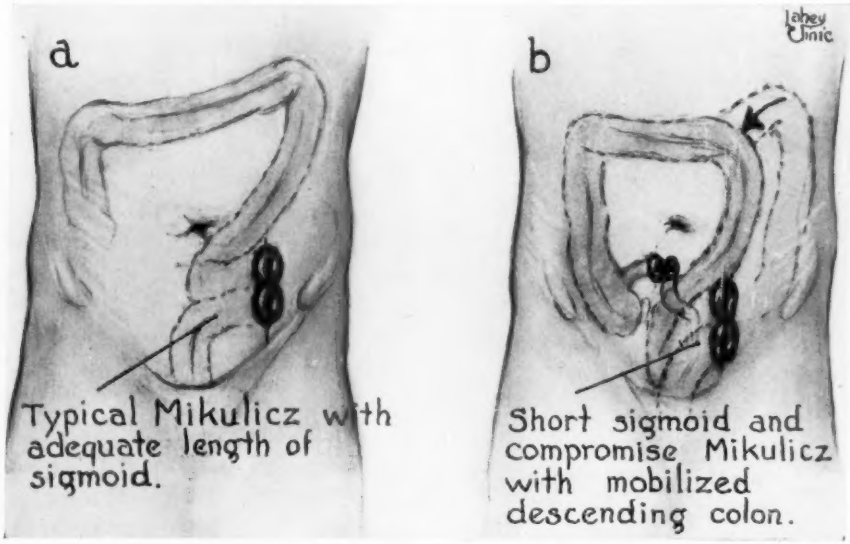
a
Typical Mikulicz with adequate length of sigmoid.
b
Lahey Clinic
Short sigmoid and compromise Mikulicz with mobilized descending colon.

FIG. 3.—Shows (a) the usual method of approximating the sigmoid loops in the typical Mikulicz procedure. This type of procedure is applicable when the lesion is sufficiently high in the sigmoid so that after its removal there is adequate length in the lower loop. (b) Shows the modification of the above typical plan when the lower loop of sigmoid is so short that it can hardly be brought up over Poupart's ligament.

Note that the splenic flexure has been mobilized and the upper loop of descending colon carried down into the pelvis and tacked onto the lower loop of sigmoid as it ascends straight out of the pelvis.

Note the sharp angle made in the mobilized descending colon where it is tacked to the lower sigmoid loop. Because of the danger of distention producing obstruction or tearing out of the approximation sutures here, note the addition of an ileostomy or cecostomy.

As the result of this experience, certain deductions have also been drawn relating to technical procedures. All colon resections in the clinic are performed with the modified Mikulicz plan of procedure. No resections with primary anastomosis are now being, or have for several years, been undertaken. It is unnecessary to mention the modification of the Mikulicz procedure with staggering of the proximal ileum which I have previously described, and it is also unnecessary to describe the type of two-stage abdominosacral removal of cancer of the rectum which I have also reported. It will be of interest, however, to mention a few of the technical procedures

which we have developed as a result of this experience, to meet certain conditions which arise in connection with the radical removal of carcinoma of the colon and rectum.

Figure 3 shows a method of restoring the fecal stream by the modified Mikulicz plan of procedure when the carcinoma of the colon is too high for an abdominosacral removal of the rectum but too low for the typical Mikulicz type of procedure. As will be seen in the illustration, if the loop of sigmoid is sufficient in length to be brought straight up from the pelvis to the level of the skin, a long loop of descending colon may be obtained by mobilizing the splenic flexure, so that the lower end of the descending colon can be placed in the pelvis beside the pelvic loop of sigmoid. These two loops are tacked together as shown in Figure 3*b*, so that when the spur between them is crushed later there will be a direct descent of feces into the rectum. These procedures have now been employed in the clinic for a number of years and have saved several patients from being otherwise forced to have a permanent colostomy. One should not fail to realize, as we have had sadly impressed upon us by such an experience, that when the loop of colon is so angulated in the pelvis, as is shown in Figure 3*b*, that it can be placed beside the straight loop of distal sigmoid, there will be an angulation at the lowest point of the proximal colon. Should distention occur, not only will obstruction result at this point but there will be marked traction upon the stitches which attach this portion of the colon to the distal colon. Failure to appreciate this fact undoubtedly caused us one fatality. One should not fail in such cases to establish a cecostomy or ileostomy, thus taking the distention and traction off the angulated colon and its approximation suture line. When the septum between the two segments of colon has been crushed and the fecal stream established, the ileostomy or cecostomy may then be closed.

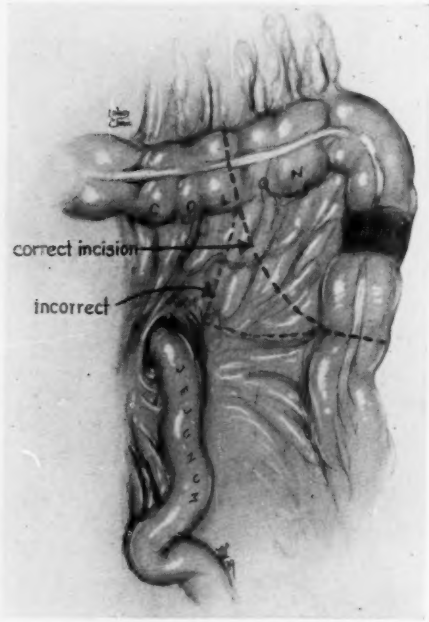


FIG. 4.—Shows the proper and improper method of removing the mesentery in resections of malignancies in the splenic flexure. Note in the improper plan, the mesentery has been taken off close to the root of the jejunum. At this level the mesentery is delicate and tears easily when sutures are introduced. When the dissection is carried out this close to the jejunum, the defect in the mesentery cannot be safely approximated. Until we learned to leave this apron of mesentery about the jejunal angle we had difficulty with sutures here and lost patients; loops of small intestines strangulating in defects here due to the sutures in the mesentery pulling out as a result of vomiting. When an apron of mesentery remains, the danger of rupturing the mesentery at this point with an angulated loop of small intestine through this defect does not occur.

Figure 5 shows a method of delayed restoration of the fecal stream when anterior resection is employed for a carcinoma of the sigmoid too high for abdominosacral removal and too low for the employment of the modified

Mikulicz type of resection. In three cases we have cut off the sigmoid just above the reflection of the pelvic peritoneum, turned the ends in carefully with buried sutures, dropped this end into the pelvis and resected that portion of the sigmoid above this, containing the malignancy, and established a colostomy in the left side. At the end of three to five years if no recurrence has taken place, the plan shown in Figure 5*c* is employed to restore the fecal stream. A preliminary Mikulicz type of ileostomy is first performed, pulling out two loops of ileum close to the ileocecal valve, attaching them together after the Mikulicz principle. The ileum, at the end of three or four days, is then opened and the entire fecal stream thus side-tracked. Irrigation through the distal ileum is then carried on, until all of the colon is entirely defunctionalized. When the colon has been thoroughly cleansed and when it contains no feces, the colostomy shown in Figure 5*b* is then dissected free from the abdominal wall through a left rectus incision, and the splenic flexure so mobilized that the proximal end of the descending colon can be approximated

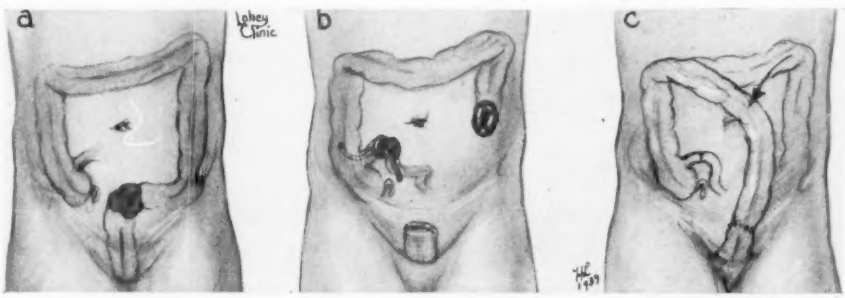


FIG. 5.—Demonstrates a method of restoring the fecal stream in low sigmoid malignancies, three to five years after anterior resections. A Mikulicz type of ileostomy is performed close to the ileocecal valve. The feces are entirely sidetracked from the colon beyond this point and defunctionalized by irrigation. The small remaining segment of rectum, after the anterior resection (b), is cleansed by enemata; and when the colon distal to the ileostomy is clean, the colostomy is excised, the splenic flexure mobilized and the proximal end of descending colon approximated to the stump of the rectum intraperitoneally. The upper closed end of rectum is cut across and an accurate end-to-end anastomosis performed.

to the stump of rectum which has been left in the pelvis. The upper closed end of the rectum is then cut across and a direct end-to-end anastomosis, with careful mucosal and muscularis sutures, can be performed safely on a bowel which does not contain feces and through which no feces will be permitted to pass until sound union between the two ends has taken place.

At the end of two weeks, when sound union has taken place, the spur in the Mikulicz ileostomy is then crushed and the fecal stream thus reestablished through the large bowel. As soon as good bowel function is demonstrated by the passage of feces and by means of a roentgenogram after a barium enema (Fig. 6), the Mikulicz ileostomy is then closed extraperitoneally. This procedure is useful, in that one can perform a radical operation upon these patients, can give them from three to five years in which to demonstrate whether or not recurrence is to take place, and at the time when the abdomen is opened for the reestablishment of the fecal stream it can be demonstrated whether or not recurrences are present. This, it has seemed to

us, is a useful and justifiable procedure in certain cases for delayed restoration of the fecal stream. It has also seemed to us a much simpler and effective defunctionalizing procedure than that proposed by Devine.

A small but useful technical procedure in patients with the colostomies associated with abdominosacral removal of the rectum and also those associated with the Mikulicz procedure is shown in Figure 7. While one can, with reasonable safety, remove the closure clamps on colostomies at the end

FIG. 6.—Roentgenogram following a barium enema showing the restoration of the fecal stream. X—site of anastomosis.

of 12 to 24 hours, it is desirable, when feasible, to give these wounds about colostomies as much time as possible in which to seal themselves off. Not infrequently the chief cause of complaint in patients with colostomies having clamps still on the implanted ends of their colons is the accumulation of gas, and in such patients, the introduction of a catheter into the ballooned colostomy by means of the purse string suture has proven useful and has permitted delay in the removal of the clamp (Fig. 7).

Perhaps there is nothing which has done more to hold back progress in operations upon patients, particularly with carcinoma of the rectum, than the question of permanent colostomy. It is unfortunate that the colostomy with which most patients, and most family physicians, are familiar is the

colostomy for inoperable carcinoma. It is unfortunate that both patients and family physicians are not more familiar with the infinitely more satisfactory colostomies which are established when the lesion is removable and has been taken out by a radical procedure. No one can compare a situation of a colostomy in a patient with an inoperable lesion with the colostomy in a patient whose lesion has been removed. In the colostomies for inoperable carcinoma it is impossible to adequately control the bowel function. Many of the symptoms of which the patient with nonremovable carcinoma complains are not associated at all with the colostomies but rather with the inoperable lesion. It is because of these facts that many of the prejudices against permanent colostomy exist.

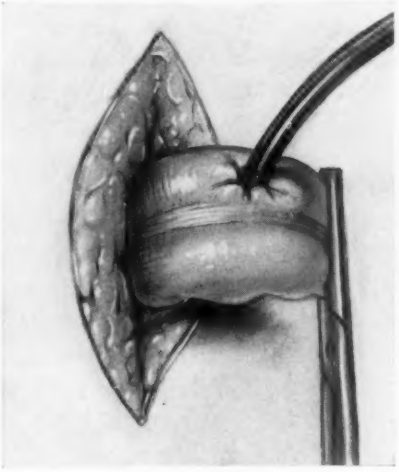

FIG. 7.—Shows the method of introducing a catheter in the gas-filled colostomy with a retaining clamp still in place. By this procedure gas distention can be overcome and the removal of the clamp with wound soiling need not be done for some days.

There are certain points concerning colostomies which have been established in instances with removable malignant lesions of the colon and rectum which need stating:

First, there are no trick colostomies whereby one can offer a patient anything in the way of bowel control. Control of bowel function is entirely related to the ability of the patient to learn how to constipate himself by a proper diet. If one performs a colostomy and discharges the patient without keeping him under supervision, preferably by personal contact, until he has learned to manage his colostomy, one can be certain that that patient, in most instances, will have a colostomy which will be unsatisfactory. One must realize that a period of four to six months must elapse before a colostomy functions most satisfactorily, and before the patient learns to so manage his diet and his colonic irrigations that he controls his bowel function satisfactorily.

I have often said that there is no place where the value of continuing interest and advice is better evidenced in a successful outcome than in the immediate six-month period following the establishment of a colostomy. Not only is it essential that these patients with colostomies have someone to whom to turn for advice during the first six months after their colostomy is established, but they must also be taught to bring their colostomy problems immediately to their adviser's attention as soon as they arise. Unless this is possible they soon become discouraged and unhappy. These patients soon learn to modify their diet so that the bowel function can be adequately controlled and, with time, even to take certain liberties with their constipating diet.

There will be occasional colostomies in which in spite of the establishment

of a good level of mucosa well above the level of the skin there will, at the end of some years, be a stricturing in the skin about the colostomy opening. In such cases patients will frequently complain that they can introduce their irrigating enema but that its return is accomplished with great difficulty. In many of these patients if the examining finger be introduced into the stoma it will be found of such small caliber that the tip of the little finger will be barely admitted. In cases of this character a plastic skin and fascial operation by means of which a section of skin and fascia is removed about the colostomy opening, thus making a wide opening to the colostomy, will usually overcome this difficulty entirely. It is of interest to report, in view of the abhorrence with which colostomy is viewed by many patients and by many doctors, that of all the colostomies which we now have functioning after radical removal of the lesions, 75 per cent of the patients wear no bags whatever, employing only a piece of gauze over their colostomy, so confident are they of the control of their bowel function by constipating dietary regimens.

One should never discuss this subject, I believe, without mentioning mortality. When the operability, three years ago, was 69 per cent, our mortality was 13 per cent. With the operability now, during the past year, at 88 per cent, the mortality has fallen to 10 per cent. Mortality rates must always be kept within reasonable limits, but when one undertakes radical removal in borderline cases to offer patients the chance of the removal of the local growth, pride in operability rates should not be permitted to interfere with the prospect of possible relief with such hazardous procedures.

Just as mortality rates should always be reported, so we believe should end-results. These may be stated simply, as they have been repeatedly published from this clinic: 47 per cent of the patients with carcinoma of the colon who have had radical operation are alive and well over five years, without recurrence, and 42 per cent of the patients with carcinoma of the rectum who have had radical operation are alive and well over five years, without recurrence.

## CONCLUSION

The relationship of polypi and adenomata to carcinoma of the rectum and colon is discussed.

The opportunity to attack the problem of carcinoma of the rectum and colon by the early discovery of the premalignant lesion and its removal by fulguration through the proctoscope or by colotomy is stressed.

The need for more routine proctologic and sigmoidoscopic examinations is evidenced by the number of polypi and adenomata which we have found and removed in the course of these routine examinations.

In 100 cases of carcinoma of the right colon, 100 cases of carcinoma of the left colon and 100 cases of carcinoma of the rectum, alteration in bowel function was noted in the history in 97.5 per cent of the cases.

The operability in the cases has risen in the last year to 88 per cent.

A few technical measures developed during the course of this experience are presented.

The public (medical and lay) needs to be made aware that life with a colostomy in a patient cured of cancer is a much more satisfactory one than is life with a palliative colostomy for inoperable carcinoma. This is a most important and generally unrealized truth. Failure to realize the change that has taken place in the sequelae following colostomy is still holding people back from being cured of carcinoma of the rectum and colon.

The mortality is stated—10 per cent! The percentage of nonrecurrence at the end of five years is 47 per cent in patients with carcinoma of the colon and 42 per cent in patients with carcinoma of the rectum.

DISCUSSION.—DR. HARVEY B. STONE (Baltimore, Md.): Doctor Lahey said that the earlier the discovery and the smaller the rectal polyp, the more radical should be the treatment, because thereby the patient had a better chance for permanent cure. The specific problem on which I should like him to comment is whether, in the case of a small, apparently benign polyp lying in the rectum, he would follow so radical a procedure. I have not felt it was good judgment to subject such a patient to an extremely radical operation. I would like him to interpret just what he means by a radical attack on such lesions.

One more word—much as I respect his judgment and opinion, and bow to his wide experience, I cannot agree that the principle of a preliminary colostomy should be invariably and without exception applied to all diseases of the large bowel. Cases in which there is no obstruction can be safely handled in general by direct attack, and in many such cases a resection can be accomplished successfully. I question whether one should adopt an invariable principle of making a two- or three-stage procedure as a rule, when there are a number of cases which experience has shown may be safely handled by direct resection at the first session.

DR. FRED W. RANKIN (Lexington, Ky.): I, of course, subscribe heartily to the thesis that the development of malignancy upon a benign polyp is a well established principle. A number of years ago FitzGibbon and I followed 13 cases of cancer of the colon and rectum through the various stages from benignancy to malignancy, confirming the work of Westheus and others, and establishing to our own satisfaction the proof that such a process takes place in a high percentage of cancers of the lower gastro-intestinal tract. Another important point, I think, in the support of this thesis, is the high number of cancers occurring in the sigmoid and rectum in the exact region where polypi are most frequently found.

In discussing types of operations and the applicability of radical surgery to low grade malignancy, I probably misunderstood Doctor Lahey in feeling that he said radical surgery should be applied to precancerous lesions. I should like to ask him, however, if he has changed his attitude toward the desirability of the one-stage operation. If I heard him correctly, his figures showed that only 20 per cent of the cancers of the rectum were operated upon by the one-stage procedure, while the two-stage operation was employed in the vast majority of cases. In 1929, I devised a two-stage radical operation for cancer of the rectum modifying Miles' procedure. In this operation a colostomy was made in the groin, the lower end of the bowel turned in and dropped back into the abdomen. One year later, Doctor Lahey modified

this procedure, bringing out the lower end of the bowel above the pubis and using it to irrigate through-and-through. I have not employed his procedure because I have hesitated to divide an obstructed bowel, and if the bowel is not obstructed more than moderately, its decompression can be accomplished equally as satisfactorily by irrigations per rectum.

Having performed my own operation in a large number of cases with a satisfactory mortality, I turned, four years ago, to the Miles operation to replace it, and since then I have performed 87 one-stage Miles operations, six of my own operations, and 25 posterior resections and colostomy by Mummery's method. In this group of Miles operations, the mortality has been 6.5 per cent, and I am confident that there is small utility for the two-stage procedure in the vast majority of instances. With adequate bowel decompression, and rehabilitation, I believe the one-stage operation can be accomplished with a mortality about equal to the two-stage radical procedure, and certainly it is a more desirable operation.

I trust Doctor Lahey will forgive me if I substitute "exteriorization" for the term "Mikulicz operation" as he uses it. Exteriorization was first done by Bloch, of Copenhagen, in 1892, and later in the same year by Paul, of Liverpool. The latter resected the bowel and put a tube in the proximal loop for drainage. Mikulicz, in 1900, reported a large number of cases successfully operated upon by this method, but gave full credit to these men for the establishment of the principle which reduced the colon mortality from around 40 per cent to 20 per cent, and has in consequence had the operation called after him, here in America only. I certainly think it should be called an exteriorization or the Bloch-Paul-Mikulicz operation, if you will. It is a useful procedure, but only for very definite indications.

It seems obvious that the increasingly satisfactory results following surgery for cancer of the large bowel and rectum, such as Doctor Lahey reports, depend upon a number of factors, not the least important of which are adequate preliminary preparatory treatment, and utilization of multiple procedures, either in one or more stages.

DR. FRANK H. LAHEY (Boston, Mass., in closing): In answer to Doctors Rankin and Stone, I am sure it is my fault that I did not make our position clearer. I did not mean to imply that we ever perform a radical operation for a benign lesion. We have performed local operations with malignancies in the tip of the polyp, not involving the base, and they have not recurred. With a frank carcinoma involving the mucosa and spreading to the base, even if only the size of the little finger nail, we do radical operations. That is the point where the family physician and the patient plead for local operation, with which we have seen recurrences in six months, to everybody's regret. Neither did I wish to imply that everyone should employ the Mikulicz procedure. The original procedure was nothing like the one to-day. It was justly criticized in its original form because of the local implantation of carcinoma in the wound with this plan of operating. With the Mikulicz operation which we and others have modified, this objection is overcome and just as radical removals may be accomplished as with any other operation. Therefore, I see no reason why anyone who likes it should not employ it. Its employment is a matter of personal selection.

As to Doctor Rankin's question, are we modifying our operative procedures? Yes. We are doing more and more one-stage operations. Just as he began with the two-stage procedure, so should we all, and as we become more familiar with the technic we will become more willing to undertake a one-stage procedure. But if we had begun with a one-stage, our mortality would

have been unduly high. We have been slow in increasing our one-stage procedures, because we have had such good results in advanced cases, advanced ages and poor risks with the two-stage procedure, and because we have had such a high operability and reasonable mortality.

We have just been in a predicament with carcinoma high in the jejunum and what we did may prove useful to others. The carcinoma was close to the ligament of Treitz, and after an adequate resection of the jejunum there was not enough jejunal stump left to do a safe end-to-end anastomosis. Had it been brought down sufficiently to do an end-to-end anastomosis, it would have retracted beneath the mesenteric vessels and caused obstruction. We were faced with a difficult situation which was overcome in the following way: We cut the ligament of Treitz, took out the segment containing the tumor and turned in the ends. We then went over to the ascending colon, turned over the hepatic flexure, approached the retroperitoneal duodenum and found it could be mobilized. We then pushed the end of jejunum beneath the mesenteric vessels, with the result that we had a well mobilized retroperitoneal duodenum with the mesentery of sufficient length to permit it to reach over in front of the transverse colon. The apron of omentum was then divided up to the transverse colon, the lower segment of jejunum brought up in front of the transverse colon as was the upper segment of duodenum, and a lateral antecolic anastomosis established between them.

I have been faced wi h this difficulty in cases of gastrojejunal ulcer. When there is a short jejunal stump it is often difficult to make a satisfactory end-to-end anastomosis. I am sure that mobilizing the retroperitoneal duodenum will give a very satisfactory lateral antecolic anastomosis or end-to-end anastomosis which will function well and much better than a difficult end-to-end anastomosis high up in the jejunal fossa.

# TECHNIC AND DEMONSTRABLE ADVANTAGES OF THE DEVINE COLOSTOMY*

REGINALD H. JACKSON, M.D.

MADISON, WIS.

I APOLOGIZE to those members of the Society whose wide experience in surgery of the colon warrants their designation as masters in this field. Doubtless they are already familiar, and have had far more experience, with the Devine colostomy than I. The decision to present our limited experience at this meeting was activated by two reasons: first, conversations with colleagues in the West revealed that many of them either missed Devine's communications in the literature or were not favorably impressed with his contribution. Possibly the nonavailability of the special enterotome essential to the proper execution of one of the steps has militated against more general adoption of the method. Second, we are thoroughly convinced that the Devine colostomy is a distinct improvement over the usual spur type, and confers so many benefits not only upon the patient but also upon the general surgeon that he cannot afford to overlook it.

During the past 30 years, I have, as a general surgeon, many times run the gamut from enthusiastic enterprise to dull despair as regards resection of the distal colon for malignant neoplasms, finally becoming resigned to the attitude of accepting such cases as a duty, but doing so without that concomitant sense of probable victory which is such a sustaining power in all surgical endeavor.

Our recent experience with the Devine procedure has renewed our interest in this field. We are convinced that faithful adherence to Devine's admonition not to resect the diseased bowel unless, and until, the distal colon is completely defunctioned and thoroughly decontaminated will remain an enduring cardinal principle in this field. While the goal attained by Devine of reducing the mortality rate of his colon surgery to one which bears comparison with the mortality rate of his other operations in the abdomen must remain a utopian dream for the general surgeon, there remains ample opportunity for him to contribute greatly in reducing the deplorably high general mortality rate.

While the outstanding results of recent years achieved by Rankin, Lahey, Dixon, and their confreres in this field are notable for a decided lowering of personal mortality rates, we must frankly face the fact that the huge majority of these patients are cared for by the general surgeon.

Any method which will insure a lower general mortality rate must be *per se* of such a nature that it is generally applicable and not directly dependent

* Read before the Southern Surgical Association, White Sulphur Springs, W. Va., December 6, 7, 8, 1938.

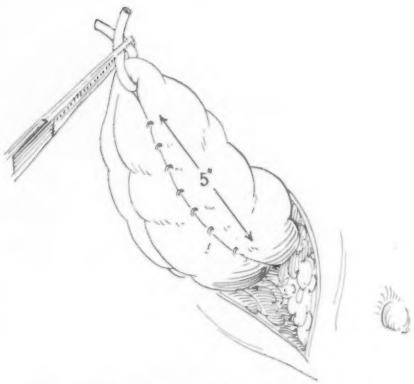


FIG. 1.—A two and one-half inch incision in upper right rectus. Loop of transverse colon withdrawn and supported on rubber tube, adjacent white lines tacked together for five inches. Loop replaced until upper tacking suture is at level of peritoneum. Mesocolon above tacking sutures has been doubly ligated and divided to permit swinging of meati into new lateral position.

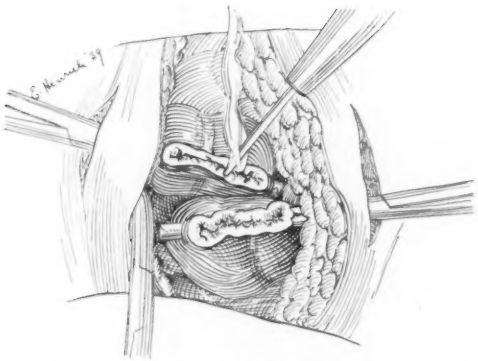

FIG. 2.—Clamps have been inserted through small lateral incisions at midwound level, grasping top of colon loop. Division and sterilization with diathermy current. Lateral incisions go through skin and fat only (not through muscles).

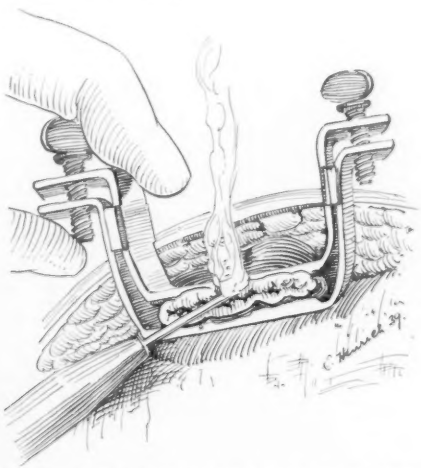

FIG. 2A.—Special Devine colon closing traction clamp in place. Sterilization with diathermy current.

FIG. 3.—After withdrawal of clamps with bowel ends, peritoneum is closed rather snugly; wound scrubbed with soap and water, and closed by layer method. Devine advocates tacking peritoneum to bowel. We have not found this necessary.

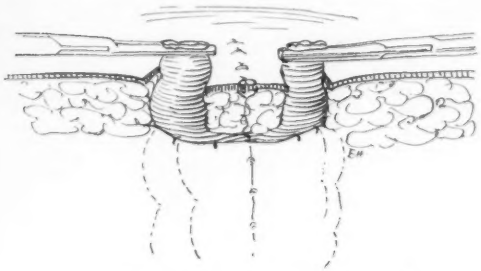

FIG. 4.—Diagrammatic section to show the two cut ends of the bowel drawn up through the small openings by Kocher clamps, and the main wound sutured.

upon the acquisition by the general surgeon of such excelling skill and technic as to approach the perfection of the masters.

The slowly improving general results achieved in the past 25 years must be credited to the acceptance by the general surgeon of the multiple-stage procedure. Where the element of obstruction is present, the establishment of a decompressing colostomy is a *sine qua non* of success in the resection stage.

No doubt these are elementary observations. Everyone knows how to make a colostomy, but only after experience with the Devine colostomy can one properly estimate the demerits of the usual spur colostomy.

As the technic and demonstrable advantages of the Devine colostomy can be far better portrayed in pictures than by words, I shall resort to the film.

TECHNIC OF THE DEVINE COLOSTOMY TO "DEFUNCTION" THE COLON

A vertical incision two and one-half inches long is made in upper right rectus.

FIG. 5.—When an acutely emergent obstructive condition is present, decompression of proximal loop is secured by passing a large catheter into the proximal meatus and threading a rubber sponge pad over it.

The glove on the left hand is vaselined to facilitate the abdominal survey.

The transverse colon is withdrawn and suspended by a rubber tube (Fig. 1).

The adjacent "white lines" are tacked together for fully five inches (Fig. 1).

The peritoneum is tacked to the bowel at the upper level of above row.

Knife punctures are made (skin and fat—not through muscles) one inch from the skin edges at midwound.

Clamps through punctures grasp the tip of the bowel loop (Fig. 2).

The loop is divided and sterilized with the diathermy knife (Fig. 2).

The bowel clamps are withdrawn and placed on the abdominal wall (Figs. 3 and 4).

The wound is thoroughly scrubbed with soap and water.

The incision is closed, first the rectus muscle and sheath above and below

the colon and then the skin, and the proximal meatus is then tacked to the skin.

A thick benzoin protective dressing is placed over the incision, leaving both meati exposed.

If the obstruction is emergent, as shown roentgenologically, the proximal clamp is removed and the proximal loop of the bowel decompressed at once.

If the transverse colon is greatly distended, Devine advises performing a simple cecostomy and a few days later performing the colostomy.

In the average case, the proximal clamp is removed after 48 hours and a suitable tube introduced through a soft rubber sponge pad (Fig. 5).

The proximal bowel is flushed out thoroughly each morning.

The tubes are corked between washings (Figs. 6 and 7).

Patients are encouraged to be up and walk around at the end of a week.

The distal clamp is removed in three days and irrigation started. Instillation of petrolagar helps to soften and remove fecal lumps. We have also found that a continuous tap water drip into the distal loop during the night helps in breaking down hard fecal accumulations.

Male patients irrigate themselves in the toilet for a half hour, twice daily. Women prefer the assistance of a nurse who inserts a small anoscope which empties into a bedpan. Elevating bed facilitates flow.

FIG. 6.—A simple method of flushing out the proximal loop every morning.

A shrunken, defunctioned bowel facilitates mobilization and resection amazingly. In two instances the preliminary survey noted that on account of the extensive growth and its "frozen" condition, it was questionable whether a resection could be accomplished later. In the most dubious case, an additional (third) week of colon flushing was instituted. The night before the day set for resection, the patient developed an acute intestinal obstruction with fecal vomiting. Operation revealed that the obstruction was due to an old appendiceal adhesion band in the right lower quadrant. It was noted on the record that the extensive, immovable "frozen mass," noted in the original survey, had been reduced fully 50 per cent and the sigmoid was somewhat

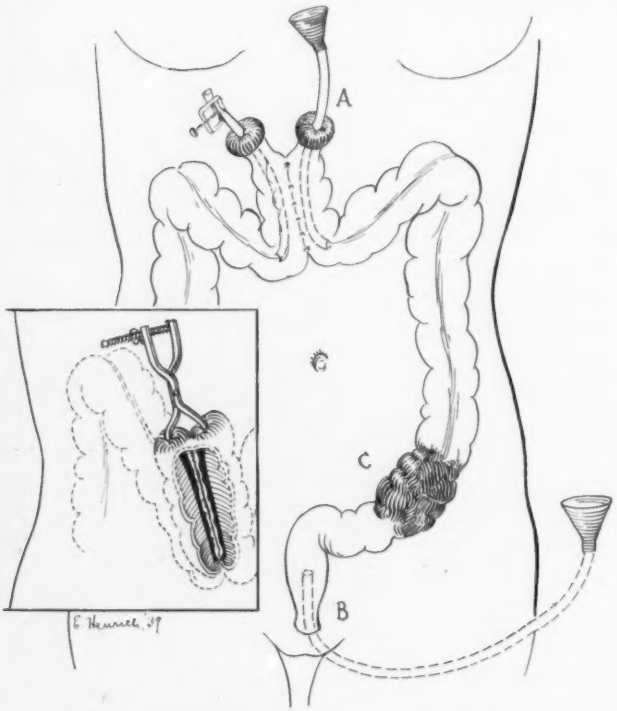


FIG. 7.—Double-barreled colostomy. Distal colon, completely defunctioned, flushed out twice daily. Proximal loop flushed once daily. Tube clamped off between flushings to prevent dehydration.

Insert: Special Devine instrument to be applied to restore continuity of colon after resection stage.

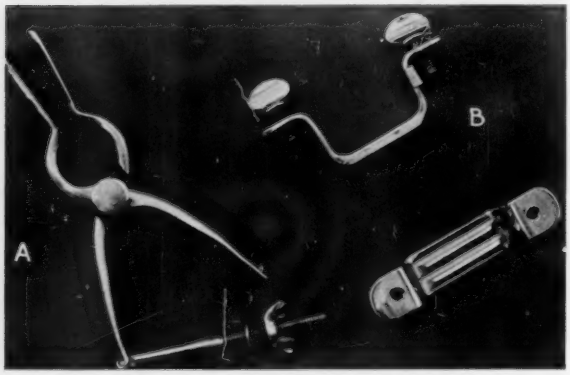


FIG. 8.—Crude, homemade Devine special instruments. A. Enterotome, to crush partition and restore colonic current after resection stage. B. Occlusion clamp used in resection stage. To be placed on proximal end of distal sigmoidal segment.*

* These instruments are now made by the V. Mueller Company, Chicago, Ill.

movable. Twelve days later, the resection proved to be very feasible. Since this experience we wait a month before performing the resection, believing that the gain thus secured outweighs any conceivable extension of the neoplastic growth itself. Patients with a continent proximal meatus are perfectly willing to wait, as they are up and around.

The left ureter and arteries are identified with the Cameron light. We always have a left ureteral catheter *in situ*.

The Devine special intestinal occlusion clamp we have found most satisfactory. This and the Devine enterotome are crude, homemade ones, as there were no special Devine instruments on the American market (Fig. 8).

A low anastomosis is made, extraperitonealized with flaps, and a drain placed. We believe, with Devine, that the surgeon will be encouraged with this method to attempt a lower anastomosis and thus save the sphincter, instead of performing a permanent colostomy and a Kraske. You will note the ideally clean aspect of the opened specimens (Fig. 12).

FIG. 9.—Application of Devine enterotome. Well vaselined blades introduced separately, then joined and screw clamp tightened each day. Usually works loose in four to five days.

One is apt to make the small incisions for the meati too large at first, but we have found that injecting quinine and urea shrinks the pouting mucous membrane around the tube in the proximal meatus.

Ten days, or more, after the resection, the Devine enterotome is applied (Fig. 9) and tightened each day; usually it works loose on or after the fourth day. Exceptionally a week is required.

Before tightening, a roentgenogram verifies the position of the blades (Fig. 10). As the "fully five inches" of suturing the white lines together may easily be followed by a shrinking to less than three, we were fearful that the blades of the enterotome might extend too far and possibly penetrate into the free peritoneal cavity. We thought it best, in the case illustrated, to draw the clamp well up before screwing home the nut.

The final step, which is undertaken after the clamp has worked loose, and the satisfactory condition of the new channel ascertained by passing a finger through the proximal meatus into and through the opening into the distal loop,

is a very simple one. Under local anesthesia, the edges of the meati are mobilized, removing any indurated skin and mucous membrane inverting the mucosal layer and closing the skin except for an iodoform wick.

*End-Result.*—Note restored continuity of colon (Fig. 11). Devine states that he usually begins injecting fluid into the lower bowel per rectum a few days after the resection, and expects that if any fluid appears in the resection wound, a fecal fistula will result. This happened in about 25 per cent of his cases.

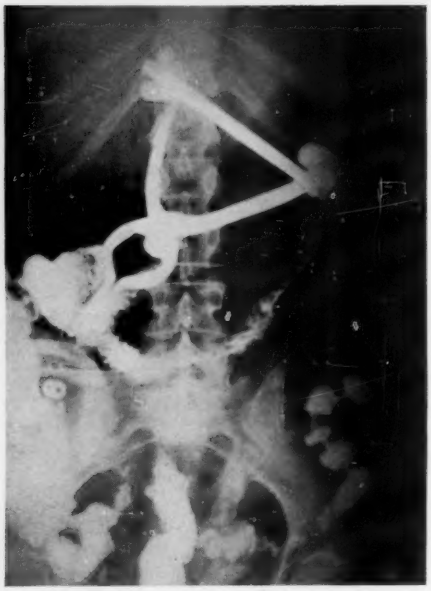

FIG. 10.—As a safety check, we introduce some barium in each meatus and before screwing the blades tight have a film made. If blades seem to project too far (possibly beyond the tacked together area), it is corrected by drawing up instruments snugly before closing it.

In one of our cases, such a serious infection occurred in the resection wound that we felt sure the anastomosis would be utterly destroyed. We refrained from applying the enterotome for six weeks, until the wound had healed thoroughly and was completely epithelialized. When the continuity of the bowel was restored, the anastomosis worked perfectly. We believe, therefore, that it is wise not to test it soon after the resection but to delay it, especially if there is any infection in the resection wound.

Figure 13 shows a wound healed *per primam*, and the Devine enterotome was used on the tenth postoperative day. Figure 14 shows the wound of a patient which became infected, as evidenced by the extensive scar formation, but who had an excellent end-result.

What, then, are some of the advantages of the Devine colostomy? They may be briefly enumerated under two headings:

I. *Benefits Conferred Upon the Patient:*

Improvement in the patient's general condition before resection is far more pronounced because:

(1) Fluid equilibrium is better maintained. Control over the proximal meatus obviates the dehydration effect often associated with the spur type.

(2) Morale is maintained at a much higher level in the absence of the more or less constant or unexpected escape of noisome gas and messy stool.

(3) At the end of a week, they may be up and around, dressed and visiting friends and other patients without embarrassment.

FIG. 11.—Roentgenogram after barium enema in case shown in Fig. 13, in which an infected wound delayed restoration of colonic flow six weeks. Arrow points to gap in mucosa where a fecal fistula would have occurred. Two months later, this gap had closed up.

FIG. 12.—Resected bowel, opened immediately after removal, shows clean, soft condition of bowel wall.

(4) Intelligent patients may go home at the end of ten days and return for the resection stage after two weeks' colon washing at home.

(5) Another economic benefit results in that they may occupy a bed in a ward instead of being relegated to a private room.

(6) A patient thus prepared presents an amazing contrast in optimism, confidence, and constitutional fortitude as compared with one prepared by a spur colostomy with its attendant mental and physical depression.

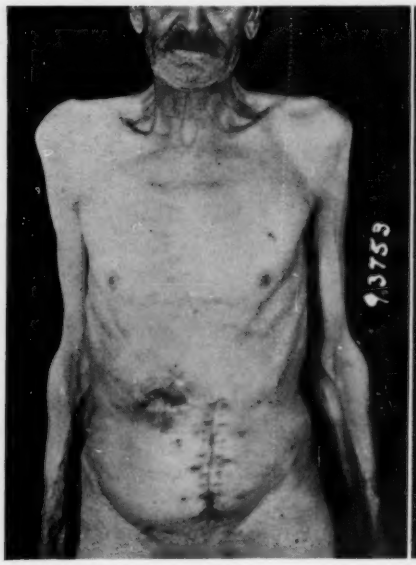

FIG. 13.—When the resection wound has healed without infection, the restoration of the colonic current is made with the Devine enterotome a week or 10 days later.

FIG. 14.—When the resection wound is infected and there is a strong likelihood of a fecal fistula forming, use of the enterotome is delayed until the wound has granulated in and is well epithelialized. In this instance, six weeks intervened.

(7) It confers a benefit on relations and friends in that it greatly reduces the horror of the treatment.

II. *Benefits Conferred Upon the Surgeon:*

(1) The distal colon, being completely detached and defunctioned, may, through repeated washings, be decontaminated more efficiently than in the spur type which, as noted by C. H. Mayo,[2] permits recontamination by the fecal stream splashing over and entering the distal loop.

(2) The position of the colostomy in the upper right quadrant insures a clean resection field with ability to mobilize the descending colon even to the splenic flexure at the resection and anastomosis stage.

(3) The completely clean and comparatively sterile condition of the

distal bowel encourages the attempt to resect and anatomose at a lower level and preserve a continent condition.

Devine, in speaking of such a prepared bowel, says: "I mean one which has been allowed to remain functionless until such time as the bacterial content has been considerably reduced, on the principle that if, experimentally, a segment of bowel be completely isolated and thus deprived of its function, in the process of time it will lose most of its bacterial content."

The victim of a spur colostomy is generally importunate in respect to time and begins very early to plead for the next stage operation. The patient with a Devine colostomy, being up and around, is very cooperative and quite content to wait the essential three or four weeks.

(4) If the resection wound develops infection and must be drained, a delay before applying the enterotome, of such time as it takes for the granulating wound to heal solidly, does not greatly discommode the patient and greatly diminishes the chance of fistula formation.

(5) The final closure of the colostomy mouths under local anesthesia is a minor procedure compared with the usual closure of a spur colostomy.

(6) In certain advanced, questionable resectable cases, it has, in Devine's experience, provided a comfortable probationary period, in that after the excision the rectal end is closed and peritonealized, the proximal sigmoidal end is implanted in the anterior abdominal wall, and the patient carries on comfortably with his established colostomy until the passage of time (six months to a year) reveals whether or not metastases have developed. If not, and if the patient's general condition warrants it, the sigmoidal end may be mobilized and telescoped into the revascularized rectal stump with good prospect of success.

While our experience with the Devine colostomy has been limited, it has been most satisfactory.

SUMMARY.—The author, after briefly alluding to the general gloomy experiences of the average general surgeon over the past 25 years in the field of colonic surgery, acclaims, after recent personal experience, the many merits of the "defunctioned" colon as devised by Devine, and expresses the belief that while the general surgeon cannot expect, through the acquisition of the skill of the masters, to parallel their results, he will, by the adoption of the procedure, make a definite contribution in lowering the present too high general mortality rate. The technic, which does not require exceptional skill, is detailed and illustrated with pictures.

## CONCLUSIONS

The ever pressing problem of how to appreciably lower the general mortality rate in operations involving the resection of the distal colon for malig-

nant neoplasms presents one hopeful aspect, in that it is more and more apparent that there is a direct relationship between the very high mortality rate of the average general surgeon in this field and the relative perfection or thoroughness of the preresection conditioning process. While the usual type of spur colostomy has been of material service in the past, the development of the "continent" proximal colostomy meatus by Devine confers so many benefits upon both the patient and the surgeon that its general adoption should be accompanied by a decided lowering of the high general mortality rate. Devine[5] estimates this to be 30 per cent in Australia.

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[3] Devine, H. B.: Carcinoma of the Colon. Brit. Med. Jour., **2**, 1245, December 28, 1935.

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[5] Devine, Sir Hugh: Personal communication.

DISCUSSION.—DR. ALTON OCHSNER (New Orleans, La.): One of the difficulties that has occurred to us has been the fact that a certain portion of the bowel is sacrificed in putting on two clamps and putting them through the lateral incision. If one will turn the loop of bowel through an arc of 90°, the loop lies longitudinally and one can place the clamps close together. A better method is a transverse incision rather than a longitudinal one, bringing the two loops out each end of the incision without contaminating the subcutaneous tissue.

The clamp we have used is a modification devised in our clinic, which is much simpler than the Devine clamp; it is made of aluminum and is very light. It can be tightened; there is a guide telling the degree of separation of the clamp. We have had 16 patients upon whom we have performed the Devine colostomy, seven for carcinoma and nine for infection. There have been seven with the first stage and nine in which the second stage was completed. One of the first-stage patients died of pneumonia several weeks after the operation.

I want to subscribe to this operation, because "defunctioning" of the bowel makes resection on the left side much safer.

DR. REGINALD H. JACKSON (Madison, Wis., in closing): One of my chief reasons for presenting this subject was to popularize the Devine type of colostomy among the general surgeons, many of whom are forced to perform an emergency colostomy for acute intestinal obstruction due to a malignant lesion in the colon, but do not feel capable of performing a later resection, referring such cases to colon resection specialists.

The Devine colostomy, in its performance, does not require any special skill. Patients thus treated will come for resection not only in far better general condition, but also with the resection area in ideal condition through "debacterialization" to better insure a successful outcome.

# THE EFFECT OF ACUTE INTESTINAL OBSTRUCTION ON THE BLOOD AND PLASMA VOLUMES

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BOSTON, MASS.

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FROM A GROUP of studies on intestinal obstruction already completed,[1, 2, 3, 4] and from experiments still in progress, we have made the following observations: (1) Ligation of the cardia and ileocecal valve (*i.e.*, closed-loop obstruction of the entire stomach and small intestine) in the cat, the gastro-intestinal tract of which has been rendered free of food, fluid and gas by a preliminary 24-hour period of starvation, does not cause notable disturbances in the gastro-intestinal tract. Death results in a few days primarily because of dehydration and starvation. (2) The introduction of various types of food into such closed loops, depending on the kind of food used, may result either in rapid death from the accumulation of gas and fluid under great tension or slow death with only moderate or insignificant quantities of gas and fluid. (3) The survival time of cats dying from gaseous distention is inversely proportional to the intra-intestinal pressure. (4) The inhalation of 100 per cent oxygen will reduce the intra-intestinal pressure in gaseous (nitrogen) distention to normal, or nearly normal, and substantially prolong the life of the animal. (5) Gaseous distention, at or above the pressure levels observed in obstruction in man and animals, does not notably increase the volume of intra-intestinal fluid, the weight of the bowel wall, or the fluid in the peritoneal cavity above the normal. (6) Dehydration alone does not account for the rapid death of such animals. (7) Denervation of the extrinsic nerve supply to the intestine does not influence the survival time of these animals. (8) We have further observed that high grade intestinal distention increases the femoral venous pressure without affecting the jugular venous pressure. Studies now in progress by the plethysmograph and by assays of water content of muscle tissue of the lower extremities suggest that distention may, by compression of the abdominal vessels, cause a loss of plasma into the tissues distal to the site of compression.

We present in this communication a study of the effects of distention, at levels of pressure observed clinically, on the volume of the plasma and on the total blood volume in dogs.

*Method.*—The plasma volume of 18 dogs was determined by the method of Gibson and Evans,[5] who used a blue dye (T–1824 or "Evans Blue"), the concentration of which in the blood was measured by the photo-electric microcolorimeter (Gibson and Evelyn[6]). This dye is nontoxic in the dosage used and very slowly diffusible. The error of other methods, arising from

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variable degrees of mixing of dye with the blood, is eliminated by taking multiple blood samples at accurately known intervals. By extrapolating the disappearance slope of the dye from the blood to the time of injection of the dye, the plasma volume can be calculated with variations not exceeding 2 per cent in duplicate samples. Since 30 to 35 cc. of blood are required for each determination, this volume was duly considered in the calculations. With the plasma volume known, the total blood volume was calculated from the measured plasma volume and hematocrit.

The normal values were determined in all but several large dogs a week before the day of experimental obstruction. In these exceptional instances this was done on the same day. All measurements were made under intraperitoneal nembutal anesthesia.

Four groups of dogs were studied (Table I). Two dogs comprise the first or control group. Nothing was done to them except to keep them under intraperitoneal nembutal anesthesia and to make plasma volume determinations every 24 hours until they died; one after 60 hours, the other after more than 72 hours. One of the two dogs (Dog 18), received 500 cc. of 5 per cent glucose in physiologic saline each day following the plasma volume determination. Two dogs comprise the second group. They were prepared as follows: After 24 hours, during which time only water was allowed so that the small intestine would be empty and collapsed, intraperitoneal nembutal anesthesia was administered and an occluding ligature placed around the pylorus. The terminal ileum was divided, the distal end inverted, a cannula was inserted into the proximal end, brought out through a stab wound, clamped off, and the incision closed. Plasma volume determinations were made after four hours and again after 23 hours. Death occurred in one after 31 hours, in the other after 34 hours.

The third group included 11 dogs. They were prepared similarly to those of Group II except that after dividing the ileum and closing the distal end a cannula was inserted into the proximal end and connected, after being brought out through a stab wound, to a Perusse pressure bottle. The entire small intestine was then continuously inflated with air at a constant level of pressure. Fifteen cm. of water pressure was used in six dogs, 20 in four others, and 30 in one. Plasma volume studies were made after four hours in nine dogs, after 13 hours in two and after 18 to 23 hours in five. The average survival time was 20.8 hours.

Three dogs treated in exactly the same manner as those in Group III, and subjected to pressure of 40, 30, and 20 cm. of water respectively, died after 10, 12 and 18 hours, with an average survival time of 13 hours. Their more rapid death was due to the unanticipated finding at autopsy of extensive venous congestion, mucosal degeneration and extravasation of blood and plasma into the intestinal lumen, mesentery and peritoneal cavity. They are, therefore, classified as Group IV, *i.e.*, as dogs with obstruction, distention and strangulation. Their short survival time permitted plasma volume determinations only once, after four to four and one-half hours.

From this and previous investigations, we learned that the resistance of the dog's intestine to increased pressure is notoriously poorer than that of the cat. Strangulation almost never occurs in the cat even at pressure levels of 80 cm. of water, whereas in five dogs, subjected to 40 cm. of water pressure, death occurred so quickly from strangulation and shock that no plasma volume determinations were possible.

The distention pressure levels used in the dogs of Groups III and IV are reasonably close to those found in various types of obstruction in man and in experimental obstruction (without artificial distention) in dogs.[7]

The dogs were kept under intraperitoneal nembutal anesthesia until death occurred. In previous studies no substantial difference had been observed in the survival time of two groups of cats similarly prepared, one under anesthesia, the other awake, subjected to the same levels of distention and pressure.

*Results.*—Table I shows that the average normal plasma and whole blood volumes of the 18 dogs studied were 5.0 and 8.8 per cent of the body weight respectively and that the average normal plasma volume was 56.8 per cent of the whole blood volume. These results are reasonably close to those of Gibson, Keeley, and Pijoan[8] and of Gasser, Erlanger, and Meek.[9] The former, using the method of Gibson and Evans, found that the normal blood volume varied between 8.4 and 9.7 per cent of the body weight. The latter (by a method probably less accurate than that of Gibson and Evans) found the average blood volume in a large series of dogs to be 9.7 per cent of the body weight and the plasma volume 60 per cent of the whole blood volume.

Part of the changes in plasma volume in these various groups of dogs are presumably due to the dehydration and perhaps pooling of capillary filtrate, especially in the dependent tissues, owing to muscular inactivity. Almost none of the dogs in the entire series discharged urine or showed a distended bladder at autopsy, so that it is not necessary to attribute any substantial part of the plasma volume changes to loss of fluid in the urine.

In control Group I, the plasma volume after 24 hours decreased 22.4 per cent in the dog which received no fluid and 18.6 per cent in the one which did, the average being 20.5 per cent. The loss of plasma for the same period in the two dogs of Group II (obstruction without distention) was 8.8 and 20 per cent, respectively, averaging 14.4 per cent. In contrast to these figures, the average plasma loss in five dogs of Group III (obstruction with distention) after 18 to 23 hours was 55.0 per cent (Table II and Chart 1).

The significance of these figures becomes impressive when translated into terms of the percentage of body weight which these losses of plasma represent; *viz.*, 0.85, 0.7, and 3.1, respectively, in the three groups (Table II and Chart 2). Johnson and Blalock[10] caused death in dogs when blood plasma equivalent to 2.4 per cent of the body weight was removed in 0.5 per cent fractions every six hours. The conditions prevailing in our experiments are comparable to those of Johnson and Blalock, who obtained their results by the removal of whole blood and the immediate reinjection of the red cells.

TABLE I

COMPARATIVE CHANGES IN PLASMA, WHOLE BLOOD, AND RED CELL VOLUMES AND IN HEMATOCRIT IN FOUR GROUPS OF DOGS

| No. of Dog | Weight | Intra-intestinal Pressure; Cm. Water | Hours After Beginning of Experiment | Plasma Volume | Reduction in Plasma Volume. In Per Cent | Total Blood Volume | Reduction in Total Blood Volume. In Per Cent | Red Cell Volume | Change in Red Cell Volume. In Per Cent | Hematocrit | Change in Hematocrit. In Per Cent | Plasma Volume (In Per Cent of Body Weight) | Total Blood Volume (In Per Cent of Body Weight) | Red Cell Volume (In Per Cent of Body Weight) | Survival Time. In Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GROUP I** | | | | | | | | | | | | | | | |
| **INTACT DOGS UNDER ANESTHESIA (NO DISTENTION)** | | | | | | | | | | | | | | | |
| 17 | 16.8 | 0 | 0 | 736 | 0 | 1,472 | 0 | 736 | 0 | 50 | 0 | 4.3 | 8.6 | 4.3 | |
| | | | 24 | 573 | 22.4 | 1,372 | 6.6 | 802 | + 8.2 | 58 | −16 | 3.4 | 8.1 | 4.7 | 60 |
| | | | 48 | 533 | 27.5 | 1,269 | 13.1 | 736 | 0 | 58 | +16 | 3.1 | 7.5 | 4.4 | |
| 18 | 15.5 | 0 | 0 | 665 | 0 | 1,279 | 0 | 614 | 0 | 48 | 0 | 4.3 | 8.3 | 4.0 | |
| | | | 24 | 542 | 18.6 | 1,032 | 18.0 | 490 | −20 | 48 | 0 | 3.5 | 6.7 | 3.2 | 72 + |
| | | | 72 | 533 | 19.0 | 919 | 28.0 | 386 | −37 | 42 | −12 | 3.4 | 5.9 | 2.5 | |
| **GROUP II** | | | | | | | | | | | | | | | |
| **OBSTRUCTION WITHOUT DISTENTION** | | | | | | | | | | | | | | | |
| 12 | 7.5 | 0 | 0 | 304 | 0 | 573 | 0 | 269 | 0 | 47 | 0 | 4.0 | 7.6 | 3.6 | |
| | | | 4 | 303 | 0 | 577 | 0 | 274 | + 1.0 | 48 | + 2 | 4.06 | 7.6 | 3.6 | 31 |
| | | | 23 | 277 | 8.8 | 554 | 3.3 | 277 | + 2.9 | 41 | −13 | 3.7 | 7.4 | 3.7 | |
| 13 | 8.9 | 0 | 0 | 408 | 0 | 816 | 0 | 408 | 0 | 50 | 0 | 4.6 | 9.2 | 4.6 | |
| | | | 4½ | 352 | 11.2 | 708 | 13.2 | 356 | −10.2 | 50 | 0 | 3.9 | 8.0 | 4.1 | 34 |
| | | | 23 | 326 | 20.0 | 633 | 22.4 | 307 | −24.7 | 48.5 | − 5 | 3.6 | 7.1 | 3.5 | |
| **GROUP III** | | | | | | | | | | | | | | | |
| **OBSTRUCTION AND DISTENTION** | | | | | | | | | | | | | | | |
| 1 | 9 | 30 | 0 | 466 | 0 | 803 | 0 | 337 | 0 | 42 | 0 | 5.2 | 8.7 | 3.5 | |
| | | | 6 | 303 | 32.8 | 584 | 27.2 | 281 | −16.6 | 48 | +14 | 3.3 | 6.4 | 3.1 | 26 |
| | | | 23½ | 253 | 45.7 | 478 | 40.5 | 225 | −32.2 | 55 | +32 | 2.8 | 5.3 | 2.5 | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 8.9 | 20 | 0 | 435 | 0 | 738 | 0 | 303 | 0 | 41 | 0 | 4.9 | 8.3 | 3.4 | |
| | | | 5 | 351 | 18.9 | 688 | 6.8 | 337 | +10.0 | 49 | +19.5 | 3.9 | 7.7 | 3.8 | 27½ |
| | | | 23 | 233 | 46.4 | 533 | 26.0 | 300 | − 0.9 | 58 | +34.0 | 2.6 | 5.9 | 3.3 | |
| 3 | 7.0 | 20 | 0 | 378 | 0 | 532 | 0 | 159 | 0 | 29 | 0 | 5.4 | 7.5 | 2.1 | 23 |
| | | | 5½ | 237 | 37.3 | 527 | 0.9 | 290 | +45.1 | 55 | +89 | 3.3 | 7.4 | 4.1 | |
| 4 | 9.3 | 20 | 0 | 603 | 0 | 939 | 0 | 336 | 0 | 35.7 | 0 | 5.8 | 8.8 | 3.0 | 10½ |
| | | | 5½ | 365 | 39.4 | 829 | 1.1 | 464 | +27.5 | 56 | +62 | 3.8 | 8.8 | 5.0 | |
| 5 | 9.0 | 20 | 0 | 713 | 0 | 1,080 | 0 | 367 | 0 | 34 | 0 | 6.0 | 9.2 | 3.2 | |
| | | | 4 | 424 | 40.5 | 986 | 8.9 | 562 | +34.6 | 57 | +68 | 4.7 | 10.0 | 5.3 | 30 |
| | | | 23½ | 284 | 60.1 | 676 | 37.4 | 392 | + 6.3 | 58 | +69 | 3.1 | 7.5 | 4.4 | |
| 6 | 10.7 | 15 | 0 | 554 | 0 | 780 | 0 | 226 | 0 | 29 | 0 | 5.1 | 7.3 | 2.2 | |
| | | | 5½ | 340 | 38.6 | 548 | 29.7 | 208 | − 7.9 | 38 | +31 | 3.1 | 5.1 | 2.0 | 19 |
| | | | 19½ | 220 | 60.6 | 429 | 45.0 | 209 | − 7.9 | 47.5 | +64 | 2.0 | 4.0 | 2.0 | |
| 7 | 12.2 | 15 | 0 | 693 | 0 | 1,066 | 0 | 373 | 0 | 35 | 0 | 5.6 | 8.7 | 3.1 | 17 |
| | | | 13 | 402 | 41.9 | 855 | 19.7 | 453 | +17.6 | 53 | +52 | 3.2 | 6.9 | 3.7 | |
| 8 | 20.9 | 15 | 0 | 1,003 | 0 | 1,928 | 0 | 925 | 0 | 48 | 0 | 4.8 | 9.2 | 4.4 | |
| | | | 6 | 455 | 53.6 | 948 | 50.8 | 493 | −46.7 | 52 | + 8.3 | 2.1 | 4.5 | 2.4 | 20 |
| | | | 18 | 377 | 62.4 | 837 | 51.3 | 460 | −50.3 | 55 | +14.0 | 1.8 | 4.4 | 2.6 | |
| 9 | 16.8 | 15 | 0 | 699 | 0 | 1,294 | 0 | 595 | 0 | 46 | 0 | 4.1 | 7.7 | 3.6 | 19 |
| | | | 4 | 469 | 32.9 | 1,116 | 13.7 | 645 | + 7.7 | 58 | +26 | 2.8 | 6.6 | 3.8 | |
| 10 | 23.6 | 15 | 0 | 1,090 | 0 | 2,180 | 0 | 1,090 | 0 | 50 | 0 | 4.6 | 9.2 | 4.6 | 18 |
| | | | 4 | 724 | 33.5 | 1,810 | 16.9 | 1,086 | 0.0 | 60 | +22 | 3.0 | 7.6 | 4.6 | |
| 11 | 11.0 | 15 | 0 | 655 | 0 | 1,101 | 0 | 446 | 0 | 41 | 0 | 5.9 | 9.4 | 3.5 | 20 |
| | | | 13 | 358 | 45.3 | 745 | 32.3 | 387 | −13.2 | 52 | +27 | 3.2 | 6.7 | 3.5 | |

## GROUP IV

### Obstruction and Distention Strangulation

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 7.5 | 40 | 0 | 352 | 0 | 645 | 0 | 291 | 0 | 42 | 0 | 4.7 | 8.6 | 3.9 | 12 |
| | | | 4½ | 126 | 64.2 | 430 | 33.3 | 304 | + 2.0 | 63 | +50 | 1.6 | 5.7 | 4.1 | |
| 15 | 10.5 | 30 | 0 | 564 | 0 | 964 | 0 | 400 | 0 | 42 | 0 | 5.4 | 9.2 | 3.8 | 18 |
| | | | 4 | 274 | 51.4 | 703 | 27.0 | 429 | + 6.7 | 61 | +45 | 2.6 | 6.7 | 4.1 | |
| 16 | 8.6 | 20 | 0 | 392 | 0 | 739 | 0 | 347 | 0 | 47 | 0 | 4.5 | 8.5 | 4.0 | 10 |
| | | | 4½ | 271 | 30.8 | 576 | 22.0 | 305 | −12.1 | 53 | +13 | 3.1 | 6.6 | 3.5 | |

The hematocrit in the dogs of Group III showed a significant increase within four hours of the onset of distention. This increase averaged 42.5 per cent after 18 to 23 hours, while the undistended, obstructed dogs (Group II)

CHART 1

AVERAGE REDUCTION IN PLASMA VOLUME

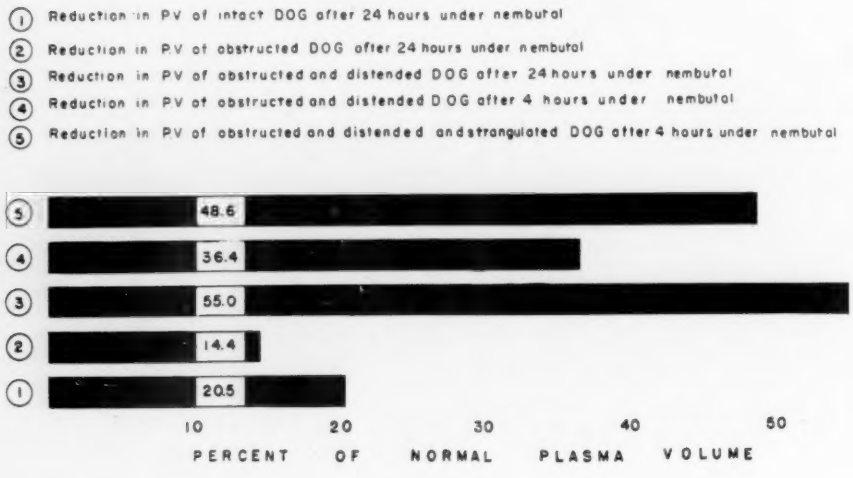
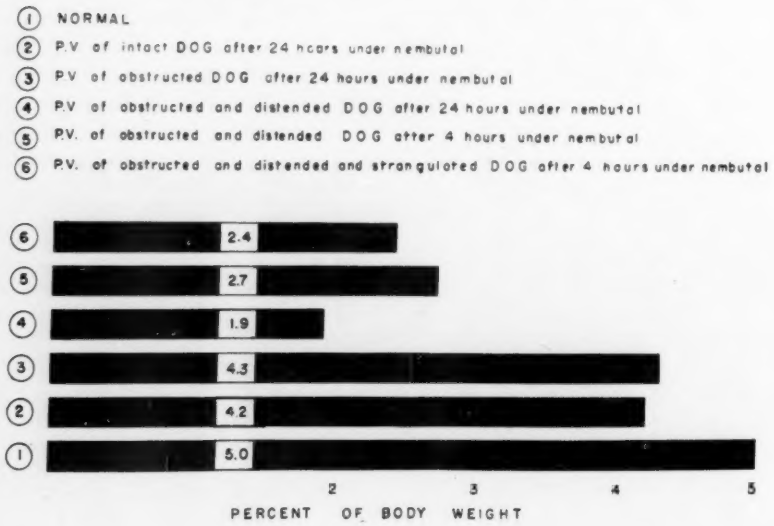

1 Reduction in PV of intact DOG after 24 hours under nembutal
2 Reduction in PV of obstructed DOG after 24 hours under nembutal
3 Reduction in PV of obstructed and distended DOG after 24 hours under nembutal
4 Reduction in PV of obstructed and distended DOG after 4 hours under nembutal
5 Reduction in PV of obstructed and distended and strangulated DOG after 4 hours under nembutal
5 48.6
4 36.4
3 55.0
2 14.4
1 20.5
10
20
30
40
50
PERCENT OF NORMAL PLASMA VOLUME

CHART 2

PLASMA VOLUME IN PER CENT OF BODY WEIGHT


1 NORMAL
2 P.V of intact DOG after 24 hours under nembutal
3 P.V of obstructed DOG after 24 hours under nembutal
4 P.V of obstructed and distended DOG after 24 hours under nembutal
5 P.V. of obstructed and distended DOG after 4 hours under nembutal
6 P.V. of obstructed and distended and strangulated DOG after 4 hours under nembutal
6 2.4
5 2.7
4 1.9
3 4.3
2 4.2
1 5.0
2
3
4
5
PERCENT OF BODY WEIGHT

showed a drop of 9 per cent and the intact, anesthetized dogs (Group I) an average rise of 8 per cent after the same interval. Table II shows the relatively small proportion of the average total blood volume loss that can be accounted for by the average loss in red cell volume when these losses are expressed in terms of percentage loss of body weight. For example, in

TABLE II

REDUCTION IN THE PLASMA, WHOLE BLOOD AND RED BLOOD CELL VOLUMES

| | Average Loss of Plasma Volume | | | | Average Loss of Total Blood Volume | | | | Average Loss of Red Cell Volume | | | | Average Change in Hematocrit | | Average Survival | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In Per Cent | | In Per Cent of Body Weight | | In Per Cent | | In Per Cent of Body Weight | | In Per Cent | | In Per Cent of Body Weight | | In Per Cent | | Period in Hours | |
| | Without Fluid | With Fluid | Without Fluid | With Fluid | Without Fluid | With Fluid | Without Fluid | With Fluid | Without Fluid | With Fluid | Without Fluid | With Fluid | Without Fluid | With Fluid | Without Fluid | With Fluid |
| Intact, anesthetized dogs | | | | | | | | | | | | | | | | |
| 24 hrs. ..... | 22.4 | 18.6 | 0.9 | 0.8 | 6.6 | 18.0 | 0.5 | 1.6 | +8.2 | 20 | +0.4 | 0.8 | +16 | 0 | 60 | 72 |
| 48 hrs. ..... | 27.5 | | 1.2 | | 13.1 | | 1.1 | | 0 | | 0 | | +16 | | | |
| 72 hrs. ..... | | 19.0 | | 0.9 | | 28.0 | | 2.4 | | 37 | | 1.5 | | −12 | | |
| Obstruction; without distention | | | | | | | | | | | | | | | | |
| 4 hrs. ..... | | 5.6 | | 0.25 | | 6.6 | | 0 6 | | 4.6 | | 0.25 | | +1.0 | | |
| 23 hrs. ..... | | 14.4 | | 0.68 | | 12.8 | | 1 1 | | 10.9 | | 0.90 | | −9.0 | | 32.5 |
| Obstruction; with distention | | | | | | | | | | | | | | | | |
| 4–6 hrs. .... | | 36.4 | | 2.3 | | 17.2 | | 1.7 | | 1.6 | | 0.00 | | +37.8 | | |
| 13 hrs. ..... | | 43.6 | | 2.4 | | 26.0 | | 2.5 | | 16.4 | | 0.20 | | +39.5 | | |
| 18–23 hrs. ... | | 55.0 | | 3.1 | | 40.0 | | 3.2 | | 17.0 | | 0.50 | | +42.5 | | 20.8 |
| Obstruction; with distention and strangulation | | | | | | | | | | | | | | | | |
| 4–4½ hrs. | | 48.6 | | 2.6 | | 27.4 | | 2.4 | | 1.1 | | 0.0 | | +39.0 | | 13.5 |

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the obstructed and distended dogs, after 18 to 23 hours, the loss in whole blood volume is 3.2 per cent of the body weight. Of this amount only 0.5 per cent is due to loss of red cells.

Dehydration cannot be held responsible for the greater loss of plasma volume in the Group III dogs, since there was no noticeable loss of fluid into the intestinal lumen, bowel wall, or peritoneal cavity in any of the first three groups, while the dehydration due to lack of fluid intake, water of perspiration, and expiratory air was presumably the same in all groups. Moreover, although Dogs 10 and 11 of Group III received 500 cc. of 5 per cent glucose in physiologic saline during the course of their distention, their loss of plasma volume was as great after the same interval as in any of those in the same group which did not receive fluid.

It is consequently obvious that the plasma volume loss is due, at least in large part, to capillary leakage of plasma in a manner similar to that occurring in traumatic shock. *Therefore, death from acute intestinal obstruction may be properly attributed to crucial changes in plasma volume due to the factor of distention alone.*

In the fourth group of three experiments in which spontaneous venous strangulation occurred after obstruction and distention, the average plasma loss after four and one-half hours was 48.6 per cent in comparison with an average loss, after the same interval, of 36.4 per cent in nine distended dogs of Group III without strangulation, and of 5.7 per cent in two obstructed dogs without strangulation or distention (Chart 1). Practically all of the loss of whole blood can, in these dogs, as in the Group III dogs, be accounted for by the loss of plasma. This suggests that the more rapid death of the strangulation obstruction dogs is due entirely to the more rapid loss of plasma. It is, therefore, probable that the clinical condition of strangulation obstruction (before the stage of peritonitis) constitutes a greater emergency than simple obstruction, not because of a fundamental difference in the pathologic physiology (*e.g.*, "toxic proteoses"), but merely because of a quantitative difference in the rate of loss of plasma.

*Discussion.*—The experimental contributions to the pathologic physiology of acute intestinal obstruction have been significant and useful, but it is all too clear in clinical practice that some vital factor still awaits clarification. Confirmation of the intoxication theory seems remote. The importance of noxious nervous stimulation cannot be ignored,[11, 12] but the available evidence regarding its rôle is conflicting.[4] If the complicating features of strangulation and peritonitis are excluded from consideration, unrelieved obstruction remains a lethal disease in spite of the effective control of electrolytic imbalance and dehydration.

There is universal agreement that the central disturbing agent in simple acute intestinal obstruction is the increase in intra-intestinal pressure and that restoration of normal tension, whether by enterostomy, intubation and suction or inhalation of 100 per cent oxygen, will restore the patient to normal,

provided the clinical condition has not reached an irreversible stage, and the deficiency in water and electrolytes is corrected.

It is important to note that most of the experimental analyses of the effects of intra-intestinal tension are based on pressure levels which are far in excess of the values observed in clinical mechanical obstruction.[7] Furthermore, it is somewhat surprising that these investigations have largely ignored the possible lethal effects of distention *per se* on the other organs of the peritoneal cavity, their lymphatics and blood supply, and on the dynamics of the general circulation.

It is a commonplace experience in the clinic and the experimental laboratory that uncomplicated intestinal obstruction (*i.e.*, without strangulation or peritonitis) is compatible with health so long as distention is prevented and the alimentary requirements are satisfied. A significant loss in plasma volume would not be expected and does in fact not occur in these circumstances. Two dogs with obstruction in the absence of distention showed, after 24 hours, an average plasma volume loss of 14.4 per cent, which is 0.7 per cent of the body weight. Two intact dogs, under light anesthesia, lost an average of 0.85 per cent of the body weight in plasma in the same interval.

But as soon as distention is produced, a rapid and extensive loss of plasma occurs. In four to six hours' time this averages 36.4 per cent of the normal plasma volume and in 18 to 23 hours 55 per cent, which is equivalent to 3.1 per cent of the body weight (Table II).

The marked difference induced by the distention factor alone is not due to a greater loss of water and electrolytes into the intestinal lumen, bowel wall, or peritoneal cavity, since the volume of fluid in these areas at autopsy was very small in all the dogs of this series except those with strangulation. Experiments now in progress to locate the site of the lost plasma and the mechanism by which distention causes the loss of plasma indicate that some of it, at least, may be incarcerated in the lower portion of the trunk and lower extremities as a result of mechanical obstruction to venous return, with resultant slow blood flow and capillary anoxemia, occasioned by the distended gut.

In two previous papers,[2, 4] evidence was given that the survival time of cats exposed to varying degrees of intra-intestinal pressure was inversely proportional to the height of pressure. It is apparent from Table II that the survival time of the dogs in the four groups is inversely proportional to the extent of the loss of plasma. This suggests a probable correlation between the volume of plasma loss and the height of intra-intestinal pressure, although we did not observe such a correlation within the limited range of pressures used (15–30 cm.).

Aird,[13] by the vital red method of Brown and Rowntree,[14] found a plasma loss of 31 and 50 per cent respectively in two of four dogs after several days of low small bowel obstruction. In the other two no significant change in plasma volume was noted. Those showing plasma loss had "gross dilatation and venous congestion" at autopsy, while the other two showed "moderate

dilatation." In the light of our experimental data, we would conclude from these statements that the degree of distention determined the extent of plasma loss. Aird's method of plasma volume determination is, however, open to the objection that the reliability of the method is questionable.

That the loss of plasma due solely to distention is of sufficient magnitude (2.34 per cent of the body weight* after 24 hours at a pressure of 15 to 20 cm. of water) to cause death is clear from the work not only of Johnson and Blalock on dogs, but also of Elman and Cole,[15] who found that cats die after a loss of plasma equivalent to 2.7 per cent of the body weight. Boyce, McFetridge, and Lampert[16] found that death occurred in dogs after removal of an amount of whole blood equivalent to 4.56 per cent of body weight. Roome, Keith, and Phemister[17] obtained nearly the same result, *i.e.*, 4.51 per cent. Harkins and Harmon[18] and others have shown that much less loss of plasma than of whole blood can be tolerated by the experimental animal. A loss of red cells is better endured than an equivalent loss of plasma.

The marked loss of plasma in the distended animals is in conformity with the rise in hematocrit which, as early as four hours after the onset of distention, averages 37.8 per cent and, after 24 hours, averages 42.5 per cent. Since the loss of red cells is negligible (Table II), the hemoconcentration is due almost entirely to the loss of plasma. The implications of this observation in clinical therapy of obstruction is clearly that the use of whole blood for transfusion purposes is not only inferior to an equivalent volume of plasma, but has the disadvantage of adding red cells, which are not only not needed, but also increase the viscosity of the blood which is already too high. In determining whether the distended patient needs whole blood or merely plasma, the hematocrit should be the determining factor.

That the loss of plasma is an early and basic process in the syndrome of intestinal obstruction is evident from the extent of the plasma loss as early as the fourth hour after the onset of distention. *It is, consequently, proper to conclude that the replacement of plasma is as essential as any other therapeutic measure,* with the exception of the all important necessity of relieving the intra-intestinal pressure. If effective decompression cannot be achieved within a short time, the patient may die from lack of sufficient plasma volume.

The extent of the plasma loss after only four hours of distention in dogs provides a rough index of the amount of plasma which may be needed by a patient with obstruction who is on the verge of, or in the state of shock, *e.g.*, the average loss of plasma in dogs with obstruction and distention after four hours, while the animal is still in good condition, is 36.5 per cent. This percentage loss of plasma in an average individual weighing 70 Kg. is approximately 1,000 cc. If restored in the form of whole blood, 1,800 cc. would be required. The deficiency of current medical practice in this connection is therefore sufficiently obvious.

* This figure is derived by subtracting the average 24-hour plasma loss in Groups I and II from that of Group III.

Experiments are now in progress to determine the value of plasma transfusions in intestinal obstruction.

Correcting dehydration, though useful and necessary, would seem to be a less vital matter at a critical stage in the process than the correction of the plasma deficiency.

The least reliable guide to impending shock in animals with obstruction is the blood pressure curve which fails to show a shock level until just before death. Since a significant fall in plasma volume is demonstrable long before the blood pressure reaches shock level, reliance on the blood pressure is misleading.

## CONCLUSIONS

(1) Dogs with intestinal obstruction die more rapidly if distended than if not distended. If strangulation is superimposed on the distention, death occurs even more rapidly.

(2) Distention of the obstructed intestine in dogs causes an early and progressive loss of blood plasma. The average loss of plasma volume reaches 36.4 per cent within four to six hours and 55 per cent within 24 hours. A 55 per cent loss of plasma is equivalent to 3.1 per cent of the body weight. Of this amount, 0.7 per cent can be attributed to dehydration; the remainder, or 2.38 per cent, is due solely to the deleterious influence of the distention on the general circulation. A loss of 2.38 per cent of the body weight in terms of plasma is sufficient to cause death.

(3) Distention *per se* does not cause a loss of fluids into the intestinal lumen, bowel wall, or peritoneal cavity.

(4) When strangulation is added to obstruction and distention, a 48 per cent loss of plasma occurs within four hours. It is suggested that strangulation obstruction in the absence of peritonitis causes death sooner than simple obstruction not because of a fundamental difference in the basic phenomena involved so much as because of a quantitative difference in the rate of loss of plasma.

(5) The magnitude of the plasma loss due to distention alone is sufficient to indicate that the all important need for immediate decompression of the gut must be accompanied by a simultaneous administration of adequate quantities of plasma. The volume of plasma necessary to restore the normal plasma volume is far in excess of the amount commonly given to obstructed patients in clinical practice. The use of whole blood has disadvantages which make the use of plasma preferable.

(6) The administration of plasma is necessary long before evidence of shock is indicated by the level of the blood pressure. The blood pressure curve is a misleading guide to the patient's condition.

(7) The use of intravenous fluids and electrolytes is necessary but not so vital as that of plasma.

(8) Distention is the central disturbing agent in uncomplicated obstruction. The mechanism by which it causes the loss of plasma is not clear. That

it is not because of a loss of fluids into the intestine and peritoneum (unless strangulation supervenes) is certain.

(9) In evaluating the need for plasma or whole blood for the correction of the blood volume changes, the hematocrit should serve as a useful guide.

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# A STUDY OF THE RESULTS OF MEDICAL TREATMENT OF DUODENAL ULCER

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THE average patient with duodenal ulcer gives a history of intermittent symptoms with a tendency to recurrent attacks separated by intervals of time during which he is relatively free of gastro-intestinal symptoms. The study of a large series of patients with ulcer over a period of years reveals that the majority of cases under medical treatment are subject to recurrent symptoms of abdominal distress if the period of observation is continued over a long period of time. The difficulty of predicting the probability of recurrence in future years in a given individual with this disease constitutes a real problem for the clinician and often gives rise to uncertainty as to what type of treatment should be undertaken in a given case. The decision by the physician to subject his patient to surgery implies the assumption that under conservative treatment the patient has a poor prognosis and that following a given type of surgical treatment the prognosis would be better. Often surgery is undertaken because the patient and physician are both discouraged with the response to medical treatment but without the slightest degree of established probability that medical treatment would continue to be unsatisfactory in the future.

The present report is based upon a study of a series of conservatively treated patients with duodenal ulcer over a period of years. An attempt has been made to analyze certain factors which appear to determine prognosis in various types of cases, for the purpose of assisting in the solution of the question as to which patients with duodenal ulcer should be treated surgically and which patients have a satisfactory prognosis under medical therapy.

This study has been carried out by the members of the Combined Ulcer Clinic of the Presbyterian Hospital over a period of more than ten years. The patients under consideration have all, at one time or another, been admitted to the wards of the Presbyterian Hospital for symptoms attributable to duodenal ulcer and in this sense are a selected group. No private patients are included and only patients whose symptoms have been severe enough to warrant hospitalization during the period of observation in the Clinic are included.

The series consists of 225 patients. The diagnosis of duodenal ulcer was based upon the demonstration of a crater or a deformity in the first

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portion of the duodenum on roentgenologic examination. It is realized that this criterion for diagnosis is not always accurate but it is the best available in the absence of an exploratory operation. The average follow-up period per patient has been approximately three years. The patients were seen in the Clinic usually at intervals of three months; oftener if they were having symptoms. Return visits to the Clinic were not contingent upon recurrence of symptoms. In fact, during the majority of revisits the patients had no significant gastro-intestinal complaints.

Ideally, the clinical course of a patient with duodenal ulcer should be recorded in terms of the amount of time in a given year in which he has had symptoms and the severity of the symptoms. This, however, is not practicable in an analysis of a large group of cases and in fact the statement of the patient is not sufficiently reliable to warrant such an attempt. We have expressed our results in terms of the presence or absence of symptoms in each year of observation in the Follow-Up Clinic. If the patient reported that he had had no ulcer symptoms over the period of an entire year this period was classified as satisfactory. If, however, the patient had any symptoms of ulcer, however mild, the entire year was classified as unsatisfactory (Chart 1). Symptoms such as belching or a mild sense of distention after meals were not interpreted as evidence of an active ulcer inasmuch as these complaints occur in so many normal individuals.

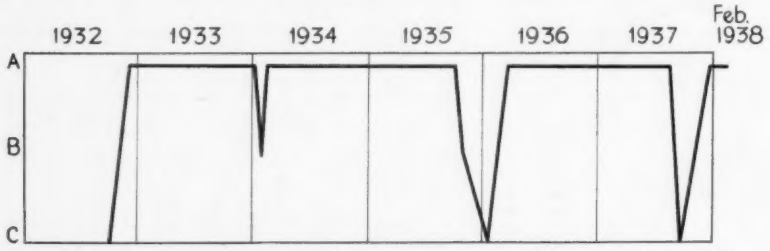


CHART 1.—Illustrating the method of charting cases for group analysis: (A) Freedom from ulcer symptoms. (B) Moderate symptoms. (C) Incapacitating symptoms.

This patient was first hospitalized in October, 1932. He was symptom-free in 1933, had moderate recurrences in 1934 and 1935 and severe recurrences in 1936 and 1937. Hence his record has included one satisfactory year, two years in which there were moderate recurrences and two years in which there were incapacitating recurrences.

The series includes 174 males and 51 females, a sex ratio of 3.5:1. Two hundred three of the patients were white, 19 were Negroes and three were Mongolians. The age distribution is shown in Table I.

TABLE I

AGE DISTRIBUTION

| | |
|---|---|
| Second decade | 4 |
| Third decade | 42 |
| Fourth decade | 79 |
| Fifth decade | 57 |
| Sixth decade | 26 |
| Seventh decade | 16 |
| Eighth decade | 1 |

The mean age of the patients when first seen in the Clinic was approximately 35. Inasmuch as all patients have been hospitalized in the wards of the Presbyterian Hospital, they represent the lower income group. Occupations of the patients are shown in Table II.

TABLE II

OCCUPATIONS

| | |
|---|---|
| Laborers (skilled and unskilled) | 78 |
| Domestics (including housewives) | 36 |
| Office workers | 26 |
| Salesmen | 23 |
| Professional | 18 |
| Chauffeurs | 14 |
| Shopkeepers | 9 |
| Miscellaneous | 21 |

There was of course wide variation in the duration of symptoms prior to observation. The duration of the disease preceding hospitalization varied from one to two days to more than 20 years according to the patients' histories. The number of patients whose symptoms were of recent onset was comparatively small. Thirty-one members of the group (14 per cent) gave a history of gastro-intestinal symptoms of less than two months' duration. The duration of illness exceeded one year in 172 cases (76 per cent).

*Method of Treatment Employed.*—During hospitalization patients were kept in bed for approximately 18 days and placed upon a modified progressive Sippy regimen. In most instances alkalies were administered at two-hourly intervals. Mild sedatives, tincture of belladonna and nightly lavage were prescribed when indicated. Shortly before discharge from the hospital an ambulatory ulcer diet consisting of six feedings per day was begun. The patients were instructed to continue this diet after discharge and were also usually given alkaline powders to take if necessary for distress. An effort was made to secure the cooperation of each patient in continuing on an ambulatory ulcer regimen as long as possible, but inevitably there was wide variation in the length of time during which patients would continue to follow a restricted diet. Most individuals followed their diet for several months after discharge and the average patient continued to take interfeedings for from four to six months. A considerable proportion of patients remained on the diet for more than six months. Gradually, however, almost all patients began to omit the interfeedings and to eat a more liberal diet, although many continued to omit from their dietary regimen a selected number of foods such as pork, fried foods and spices.

*Results for the Entire Group.*—Of the 225 patients included in this study, six have died as the result of ulcer, a mortality rate of 2.7 per cent. Three deaths were due to hemorrhage, one to rupture of the esophagus associated with vomiting, one to tetany and in one case the explanation for death was uncertain. Only seven members of the group have been subjected to surgery.

The total amount of time for which the entire group of patients has been followed is 842 years, giving an average of three and one-third years per patient. Individual follow-up periods have varied from a few months to 15 years.

During 503 follow-up years (or 60 per cent of the entire time) there has been complete freedom from symptoms of ulcer. In other words, our patients have remained symptom-free approximately one out of every two years. It should also be emphasized that most patients have been symptom-free during the major portion of those years in which recurrence took place.* Furthermore, the majority of the recurrences have not been severe enough to interrupt normal activities and to incapacitate the individual. A more precise estimate of the severity of the symptoms is shown in Table III, in which the follow-up years are classified according to the severity of the symptoms.

TABLE III

ANALYSIS OF SEVERITY OF SYMPTOMS DURING FOLLOW-UP YEARS

| Number of Cases | Years of Freedom from Ulcer Symptoms | Years in Which Moderate Recurrences Took Place | Years During Which Patient Had Incapacitating Recurrences | Total Follow-Up Years |
|---|---|---|---|---|
| 225 | 503 (60%) | 216 | 123 (15%) | 842 |

It will be noted that the number of years in which patients were ill enough to be incapacitated was comparatively small, being only 15 per cent of the total (equivalent to one out of every seven years).

The foregoing figures, expressing results in terms of time, portray a fairly satisfactory follow-up for the group as a whole. However, they fail to show the tendency to recurrence in the large majority of cases. For this reason it is of interest to consider the proportion of cases who have remained

TABLE IV

ANALYSIS OF THE NUMBER AND PERCENTAGE OF PATIENTS IN THE GROUP REMAINING CONTINUOUSLY WELL OVER A PERIOD OF YEARS

| Years of Follow-Up | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| Number of patients | 140 | 90 | 79 | 59 | 43 | 33 | 25 |
| Number of patients remaining free from recurrence | 49 | 37 | 25 | 13 | 11 | 7 | 6 |
| Percentage remaining free from re-recurrence | 35% | 40% | 31% | 22% | 25% | 21% | 24% |

*This is clearly shown when the results are analyzed by three-months periods instead of years. The results by three-months periods for the entire group are: Satisfactory periods—81 per cent; periods in which moderate recurrences took place—14 per cent; periods in which incapacitating symptoms occurred—5 per cent.

continuously symptom-free over a period of years. These results are shown in Table IV.

One hundred forty patients have been followed for more than two years. Sixty-five per cent of them had recurrences within the first two years of the follow-up period, leaving only 35 per cent who remained free from symptoms. The table shows the number of patients followed for more than two to more than eight years. Of the patients who were followed for more than five years, only 25 per cent of them have remained continuously free from symptoms. This tabulation illustrates the tendency for most of the patients to ultimately have a recurrence of the disease.

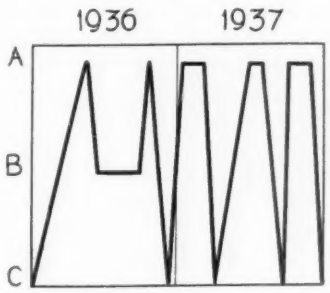


CHART 2.—Persistent Pain During Hospitalization:
O. D. (Unit No. 477771), was admitted in February, 1936, for pain due to duodenal ulcer. Pain persisted for 25 days in the hospital. The subsequent course has been very unsatisfactory and the patient has been hospitalized on four other occasions.

*Patients with Persistent Pain under Hospital Management.*—The average follow-up expectancy in a group of patients who have received medical treatment for duodenal ulcer has comparatively little application to the individual case. The clinician is confronted with such individual problems as the patient with persistent pain in spite of hospital management, the patient who has had a gross hemorrhage without much pain, or the patient who has persistent pyloric obstruction not yielding to conservative therapy. Our entire group of patients has, therefore, been subdivided into smaller groups representing one or another of these clinical problems.

One of the commonest problems in the treatment of this disease is that presented by the patient who suffers from persistent abdominal pain in spite of ideal conservative treatment. We have found that our patients with

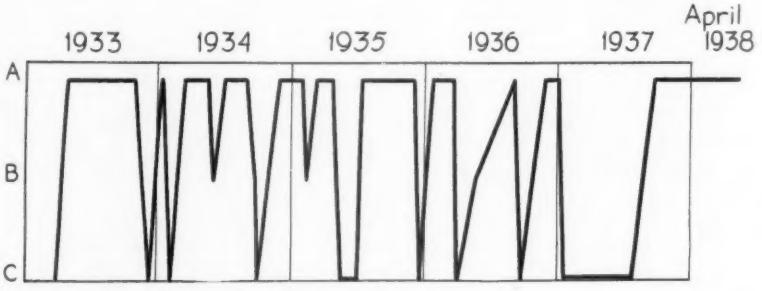


CHART 3.—Persistent Pain During Hospital Treatment:
E. L. (Unit No. 372307), was admitted in 1933 for duodenal ulcer of three and one-half years' duration. Pain persisted for three weeks while in the hospital. Subsequent course has been very unsatisfactory, there having been one or more incapacitating recurrences each year.

persistent pain under hospital treatment have a very unfavorable prognosis. Although not discharged from the hospital until their symptoms had completely subsided, those patients who had stubborn symptoms, yielding more slowly to treatment, suffered recurrences in succeeding years much more frequently than did the average patient (Charts 2 and 3). For purposes of

analysis, all patients who continued to have pain in the hospital on a modified Sippy regimen for more than two weeks and also any patient who suffered a recurrence of pain in the hospital after the first two weeks of treatment were classified in the persistent pain group. There were 57 such patients followed for an average period of three and one-half years. They remained free from symptoms of ulcer during only 30 per cent of the time (as compared with 60 per cent for the entire series). The details of analysis are shown in Table V.

TABLE V

RESULTS IN PERSISTENT PAIN GROUP

| Satisfactory Years | Years in Which There Was Moderate Recurrence | Years in Which There Was Incapacitating Recurrence | Total |
|---|---|---|---|
| 57 (30%) | 87 | 49 (25%) | 193 yrs. |

Not only was the frequency of recurrence much greater in this series of patients with persistent pain than in the average case, but the recurrences were more severe.

There are of course a number of patients in the persistent pain group whose individual results have been satisfactory, and the conclusion cannot be drawn that all patients with persistent or recurrent pain while under hospital treatment have a bad prognosis. In many of our cases, however, the results were so discouraging that surgical intervention should probably have been considered.

On further analysis, it was found that patients in this group with persistent pain who suffered a recurrence of symptoms during the first six months after discharge from the hospital had even more unsatisfactory results. In fact, the clinical course in such patients was so uneven and characterized by such frequent and severe recurrences that there remains no doubt that surgical treatment would have been preferable in most instances. There were 29 patients in the persistent pain group who had a recurrence within six months of discharge from the hospital. The follow-up results are shown in Table VI.

TABLE VI

| Satisfactory Follow-Up Years | Years During Which Patients Had Moderate Recurrence | Years of Incapacitating Recurrence | Total Follow-Up Years |
|---|---|---|---|
| 11 (14%) | 44 | 23 (29%) | 78 |

Careful analysis of the group with persistent pain revealed no other common characteristic which would have been suggestive of more serious disease. The average age was 42, not much older than the average in our

entire series of cases. The incidence of gross hemorrhage was not remarkable. Two-thirds (32) of the patients had never suffered from gross hemorrhage, nine had had a single gross hemorrhage and the remaining eight had had two or more hemorrhages. This incidence of hemorrhage is approximately of the same frequency as that of the entire series. Recognized psychiatric disease in this group was not particularly common. Four patients were diagnosed as having an anxiety neurosis and one patient had manic depressive insanity in a mild form. Only a few of our patients, however, have been studied by a psychiatrist.

The care with which dietary treatment was followed by this group of patients after discharge from the hospital varied, but in the majority of cases could be considered satisfactory, as only 13 of the 57 patients admitted having broken their diet during the first six months. Twenty-five patients reported careful adherence to the diet as prescribed, for at least six months after discharge, and in many instances the patients remained on this diet for more than a year. Ten patients followed the ambulatory ulcer diet for at least six months but omitted interfeedings at times. Information concerning

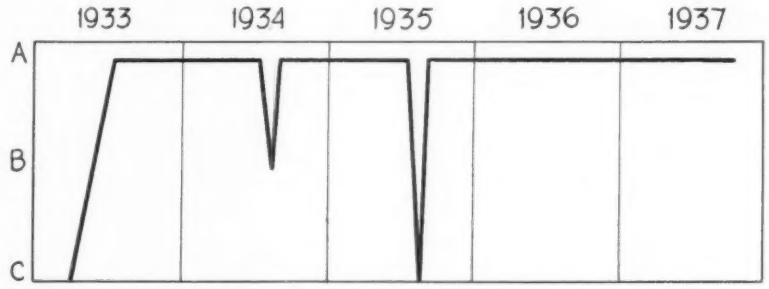


CHART 4.—Immediate Response to Hospital Therapy:
O. M. (Unit No. 372438), was admitted for a duodenal ulcer of 12 years' duration. No history of gross hemorrhage or obstruction. Subsequent course was fairly satisfactory. Patient has had one moderate and one severe recurrence in five years.

diet was incomplete on nine patients. In general it may be said that this group of patients were as conscientious about dietary treatment as can be expected. The results of treatment cannot be regarded as satisfactory.

*Immediate Relief of Pain under Hospital Treatment.*—Inasmuch as there appeared to be a relationship between persistence of pain in patients with duodenal ulcer on hospital treatment and their prognosis, it was also of interest to analyze the results in those patients who had prompt relief of symptoms immediately after hospital admission. It was found that those patients who were admitted to the hospital because of abdominal pain and whose symptoms were relieved within 24 hours of admission appeared to have a very good prognosis (Charts 4 and 5). There were 36 cases falling within this group; namely, patients with relief of pain within 24 hours of admission and without any complication such as gross hemorrhage or pyloric obstruction. Some of the patients in this group had slight gastric

retention shown roentgenologically. The presence of a small barium residue on one examination, absent on the next examination, was not considered significant.

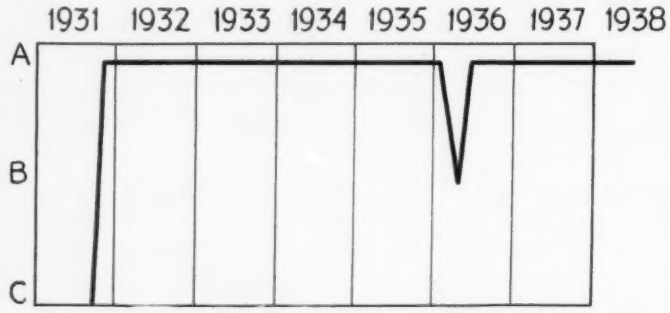


CHART 5.—Immediate Relief of Symptoms After Hospitalization: C. S. (Unit No. 318587), was admitted for symptoms of five years' duration. No history of gross hemorrhage or obstruction. Has been satisfactory for six out of seven follow-up years.

This group of 36 cases has been followed for a total of 193 years, representing an average follow-up period of five and one-third years per patient. The results are shown in Table VII:

TABLE VII

| Satisfactory Years | Years in Which There Were Moderate Recurrences | Years in Which There Were Incapacitating Recurrences | Total Years |
|---|---|---|---|
| 148 (76%) | 29 | 16 (8%) | 193 |

Expressed otherwise, patients in this group suffered a recurrence of symptoms once in every four follow-up years. Incapacitating recurrences took place less than once in every ten years. It appears then that the patient who is admitted to the hospital for an uncomplicated duodenal ulcer and whose symptoms subside almost immediately after admission to the hospital has an excellent prognosis under medical treatment.

*Gross Hemorrhage.*—Ninety-one patients in this series suffered from a gross hemorrhage at some time during their period of follow-up observation. Death resulted in three cases, a mortality rate of 3.3 per cent. There were five additional cases who gave a convincing history of hemorrhage but who have not bled since they have been under observation. In the majority of instances gross hemorrhage occurred only once. A small group, however, have suffered from repeated hemorrhages.

The patient who has had a series of gross hemorrhages from duodenal ulcer constitutes a serious therapeutic problem, involving the choice between surgical treatment and the continuation of medical therapy. There are only 18 patients in our series who were under observation after having had three

or more gross hemorrhages. This group is small because it has been the usual practice to treat such patients surgically and very few have been observed under continued medical treatment. The total follow-up period for this group of 18 patients has been 34 years, 60 per cent of which were satisfactory. Detailed results are shown in Table VIII.

TABLE VIII

| Satisfactory Years | Years in Which Moderate Recurrence Took Place | Years in Which Severe or Incapacitating Recurrence Took Place | Total Follow-Up Years |
|---|---|---|---|
| 20 (60%) | 5 | 9 (26%) | 34 |

The incidence of recurrence in our patients who have had multiple gross hemorrhages was no larger than the average for the entire series. At first hand, these results appear to be in conflict with the clinical impression generally held that patients with repeated hemorrhage due to duodenal ulcer have a poor prognosis. It should be noted, however, that the incidence of severe and incapacitating recurrence in these patients was large. In 26 per cent of the follow-up years the patients were incapacitated by recurrent symptoms of ulcer. It appears, therefore, that while the incidence of ulcer recurrence in patients with multiple hemorrhage is not greater than the average hospitalized case of duodenal ulcer, such patients are more apt to have very severe symptoms in subsequent attacks. In this sense, the outlook for the patient who has had multiple gross hemorrhages may be considerably worse than that of the individual who has an uncomplicated duodenal ulcer. This problem merits further study with a larger series of cases.

On the other side of the picture is the outlook for the patient who is suffering from an initial gross hemorrhage. His prognosis appears to be very satisfactory, particularly if the hemorrhage is not accompanied by pain or obstruction. There were 28 cases followed after admission to the hospital for an initial gross hemorrhage and who had no pain during hospitalization. This group includes both those patients who had never had any previous symptoms of duodenal ulcer and also those patients who had previously suffered from abdominal pain but who were not suffering from pain at the time of hospitalization. Results in these patients are among the best in our entire series (Table IX).

The question arises as to whether patients who have had a single gross hemorrhage are more apt to have recurrent bleeding in the future than are patients with duodenal ulcer who have never bled. Although our series of cases is too small to answer this problem positively, it is of interest to note that of the 28 patients in this group admitted for an initial hemorrhage, seven (or 25 per cent) have suffered from subsequent hemorrhage during the

TABLE IX

| Satisfactory Years | Years in Which There Were Moderate Recurrences of Symptoms | Years of Severe Recurrence |
|---|---|---|
| 80 (76%) | 15 | 11 (10%) |

follow-up period. In contrast, the incidence of hemorrhage during follow-up in patients who had not bled prior to hospital admission has been very low. Of our group of 36 patients with uncomplicated duodenal ulcer who had immediate relief of pain on hospital admission, only one has had a subsequent gross hemorrhage.

Another problem occasionally encountered in the hospital treatment of peptic ulcer is that of persistent bleeding. Six patients in this series presented evidence of persistent bleeding during hospital treatment unassociated with persistent pain or obstruction. The average patient admitted for gross hemorrhage from duodenal ulcer shows evidence of occult blood in the stool for five to seven days after admission. For the purpose of the present analysis, patients who had a positive guaiac test in the stool after two weeks of hospitalization were classified as having persistent hemorrhage. None of the six patients falling within this classification has had an unsatisfactory follow-up result after discharge from the hospital. The number of patients, however, is too small to justify any conclusion concerning the prognostic significance of persistent hemorrhage in patients with duodenal ulcer.

*Persistent Pyloric Obstruction.*—There are very few patients in this series who had persistent obstruction during hospital treatment. High grade pyloric obstruction in duodenal ulcer has long been an indication for surgical intervention. A few patients, however, in this medically treated series had persistent obstruction throughout hospital treatment. There were four patients who had at least a 50 per cent retention of the barium meal on roentgenologic examination at the end of six hours, persisting after at least two weeks of hospital treatment. Hospital treatment consisted of rest, diet, belladonna and nightly gastric lavage. The lavage was continued after the patients became ambulatory. All four patients had very unsatisfactory follow-up results.

Six other patients had an intermediate grade of pyloric obstruction as judged roentgenologically. On entrance into the hospital, they were found to have a six-hour retention to 25 to 50 per cent of the barium meal. This degree of obstruction persisted after hospital treatment. The amount of obstruction in these cases was not as severe as in the first group. Response to treatment was, however, not very satisfactory (Chart 6). Of the six patients, three had a satisfactory follow-up course and the other three continued to have symptoms of obstruction associated with pain.

*Discussion.*—The results of this survey indicate in a general way the prognosis for patients who are suffering from severe symptoms due to duodenal

ulcer. The results do not apply to all patients with this disease, inasmuch as we have been dealing with a selected group. We have purposely excluded from present consideration any patient under observation in the Clinic whose symptoms have never been severe enough to warrant hospitalization.

Furthermore, our group does not include patients who have been under private care during the period of study. Whether or not the prognosis in a group of individuals with duodenal ulcer whose economic status differs from that of persons eligible for clinic and ward care is a question that cannot be answered at the present time.

The average period of follow-up per patient in our series is comparatively short, being only a little more than three years. Our data, therefore, can only

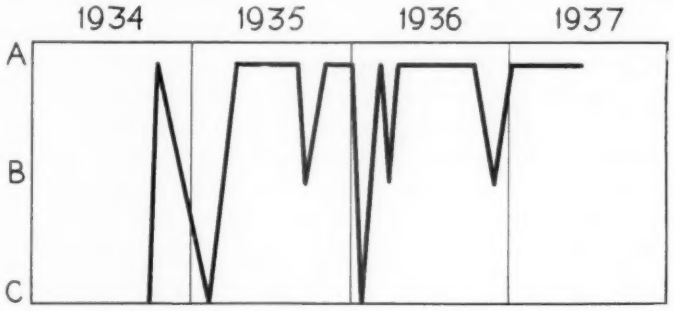


CHART 6.—Persistent Obstruction:
A. P. (Unit No. 419033), age 41, had initial symptoms 15 years ago. First admission, in October, 1934, was for moderate pyloric obstruction. On diet and lavage, the obstruction persisted (six-hour barium residue of 25 per cent). Eventually, the patient became symptom-free. His subsequent course has been one of frequent recurrences usually moderate in severity. At present, the patient still has slight obstruction demonstrable roentgenologically.

be applied with any degree of certainty in problems of immediate prognosis. Whether the expectancy of recurrence changes in a group of individuals under observation over a longer period of years will have to be determined by further study. There are indications, however, that in any large group of individuals with duodenal ulcer under conservative treatment, the number of recurrences remains approximately the same at any one time. Insofar as our follow-up studies have been carried, we have found that in any given six months' period, approximately 25 per cent of our patients suffer from symptoms attributable to ulcer, the remaining three-quarters of the group being symptom-free. This is true both of the first six months of follow-up after hospital treatment and of succeeding years.

Among the patients whom we have included in this study, the worst results were obtained in the group with persistent pain and the group with multiple hemorrhage. Results in our series of 57 patients with persistent pain during hospitalization have been so poor that in the future we feel that surgical therapy should be seriously considered for any patient who falls within this group. The combination of persistence of pain during hospital treatment and early recurrence after the patient becomes ambulatory has been followed by even worse results. In fact, our experience with almost every patient who

has fallen into this category has shown that it would have been wiser to have subjected the patient to surgical intervention. Contraindications to surgery did not exist in the majority of patients in this group.

Our data concerning patients with multiple hemorrhage are rather surprising, in that they show no greater frequency of recurrence in this group than in the average case in the series. There is, however, no logical reason to assume that a patient who chances to bleed during a recurrence of ulcer on several occasions should be more prone to have frequent recurrences in the future. The important consideration is that when this type of patient does suffer a recurrence, the symptoms are more apt to be severe and the patient is again apt to have associated bleeding. It is this hazard that makes the patient with multiple hemorrhage a candidate for elective surgery.

Our number of patients with persistent pyloric obstruction associated with duodenal ulcer is too small to justify further comment. Persistent pyloric obstruction has long been one of the primary indications for surgical therapy in duodenal ulcer. Our very unsatisfactory experience with patients in this group under medical treatment is in accord with this general view. It should be pointed out, however, that marked pyloric obstruction frequently yields to treatment with bed rest and periodic gastric lavage. Patients of this type do not, of course, fall into the group with persistent obstruction. Operation for pyloric obstruction should usually be deferred until it has been demonstrated that such obstruction persists after adequate medical therapy.

It should again be emphasized that the majority of cases of duodenal ulcer, even in this selected series of patients with severe symptoms, respond very promptly to medical treatment in the hospital. It is the exceptional patient who continues to have pain or vomiting for two weeks or more after the institution of bed rest and frequent feedings. Certain it is that the disappearance of symptoms under treatment precedes by a considerable period of time the complete healing of the ulcer. The mechanism by which this relief of symptoms is effected is not entirely clear, but has been attributed in part to relief of pyloric spasm and neutralization of gastric acidity. The important rôle of mental relaxation which usually occurs following hospitalization should not be overlooked.

The correlation between the symptomatic picture and the pathologic lesion is also difficult in those patients with persistent pain followed by early recurrence. The question arises in these individuals as to whether there has been a persistence of the same ulcer or whether the original lesion has healed and a new ulcer has developed. Roentgenologic examination of the duodenum has not reached the degree of precision required to answer this problem. In view of the fact that many ulcer craters in the duodenum are not visualized roentgenologically (the examination often showing only a duodenal deformity), the radiologist is unable to determine whether patients in this group have a persistent or a recurrent ulceration. With future improvements in roentgenologic diagnosis or other methods of examination, it may become possible to segregate the group of patients with duodenal ulcer who have lesions which fail to heal

on medical therapy. Such patients would be candidates for surgery. In all likelihood many of our patients with persistent pain under hospital treatment would fall within this group.

## SUMMARY

(1) Follow-up results in the selected series of 225 patients with duodenal ulcer under medical treatment are reported.

(2) The majority of patients who were followed for more than two years developed recurrent symptoms. In most instances recurrences were mild and readily controlled by further medical therapy.

(3) Approximately 75 per cent of patients were symptom-free during each six months' period of follow-up observation.

(4) Detailed study revealed that certain selected groups of patients had an unsatisfactory prognosis in comparison with the other patients in the series.

(a) The majority of patients with persistent pain lasting for more than two weeks during hospital treatment had an unsatisfactory follow-up course. When patients of this type suffered an early recurrence of symptoms after discharge from the hospital, the results were even worse.

(b) Patients who had had three or more gross hemorrhages due to duodenal ulcer were not more prone to have recurrences than the average patient in the series. When recurrence took place, however, the symptoms were more apt to be severe.

(c) Prolonged medical treatment was undertaken in a few patients with persistent pyloric obstruction. The results were unsatisfactory.

(5) Certain groups of patients were found to have a prognosis which was better than average.

(a) Most patients with uncomplicated duodenal ulcer who had complete relief of pain within 24 hours of hospitalization had very satisfactory follow-up results.

(b) The majority of patients who were hospitalized for an initial gross hemorrhage without associated pain or obstruction had a very satisfactory follow-up course.

(6) Surgical therapy should be considered for patients falling into the categories enumerated under (4); namely, persistent pain, multiple hemorrhage and persistent pyloric obstruction.

# INTERNAL BILIARY FISTULAE AND INTESTINAL OBSTRUCTIONS DUE TO GALLSTONES

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THE impaction of a gallstone as a cause of intestinal obstruction has long been recognized. An early, correct diagnosis has seldom been made. As a result, the patient is not sent to the hospital until in a dangerous condition. Wakeley and Willway[7] state that: "Most stones entering the intestinal tract are passed naturally, with no symptoms except the initial attack of biliary colic. Stones which are large enough to cause obstruction never pass the entire length of the common bile duct but ulcerate through from the gallbladder or a duct into the bowel."

There are two points which we wish to stress particularly relative to these cases: First, the intestinal obstruction; and second, the internal biliary fistula which is present. Not infrequently, a large stone has been found in the intestinal tract without having produced any untoward symptoms.

The records relative to the frequency of intestinal obstruction due to gallstones apparently vary rather widely. Osler[18] reported 23 cases due to gallstones out of a total of 295, or 7.8 per cent. Vick,[17] in a symposium on intestinal obstruction, in 1932, reported 47 out of 3,625 cases, or 1.3 per cent. Combining the statistics which we have gathered from various authors, it is found that out of a total of 7,232 cases of intestinal obstruction, 149 were due to gallstones, or 2 per cent of all obstructions. The mortality is in the neighborhood of 50 per cent and is largely the result of delay. The history is not typical of intestinal obstruction and the true diagnosis is difficult. We have records of 41 cases of complete or partial obstruction of the bowel during the past three years; two cases, or about 5 per cent, were due to gallstone impaction. The average age of all cases reviewed was 66 years; 80 per cent were females.

In practically every case in which the location of the obstruction was mentioned, it was within two feet of the ileocecal valve, most frequently about 12 inches from the cecum. In a large percentage of cases, the history of obstruction is intermittent. In most, there was an antecedent history suggesting gallstone colic, often several years previously, then recurrent attacks of so-called indigestion with distention, nausea and vomiting, with severe cramp-like pains which frequently ceased as suddenly as they had begun. The most common diagnosis was food poisoning. In many cases the history was vague, consisting of the occurrence of chills and fever, suggesting malaria or an infected gallbladder. After recovery from this, there followed recurrent headaches with vague abdominal pain, nausea and vomiting. These episodes were usually diagnosed as migraine. After a period of from three to 15 years

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with symptoms suggestive of gallbladder disease, a complete obstruction of the bowel occurred. From the histories reviewed one would gather that the obstruction was incomplete at first. Relief is afforded by the stone moving back into a larger segment of the intestine by retroperistalsis. Finally, the stone is propelled into the narrow part of the ileum and becomes lodged. If recognized early, the operative removal of the stone is comparatively simple.

The stone finds entrance to the intestine by ulcerating through the gallbladder wall into some part of the intestinal tract, most frequently into the duodenum. Usually a short fistulous tract is found; sometimes there is a direct opening. The findings at autopsy, as reported by Courvoisier,[20] in 36 cases, are of interest in this connection. The fistula entered the duodenum in 25 instances, the ileum in one, into both the colon and duodenum in two, the colon in one, and no fistula was demonstrable in seven cases. In most instances, a dense mass of adhesions firmly bound the gallbladder and duodenum together, enclosing a cystoduodenal fistula. Of the 149 cases of internal biliary fistulae reported in the literature, the gallbladder was always involved. Therefore, while in theory a stone may ulcerate through the common duct into the intestine, not one case was found recorded. Every internal biliary fistula found was from the gallbladder to some part of the intestinal tract.

Bernhard[2] reported finding 109 internal biliary fistulae in 6,263 cases of surgical intervention upon the biliary passages, or 1.8 per cent. In most, there was an intermediate canal. The gallbladder opened into the duodenum in 56 instances, into the colon in 36, into the stomach in 12, and into several fistulous tracts in five. In addition to excision of the fistula, the principal bile tract was drained in 60 cases. The mortality was about 10 per cent.

There is a general impression that life expectancy is rather short after an internal biliary fistula has been established. This is largely due to the fact that in dogs an ascending infection through the bile passages occurs and death follows rather early. We may seriously question the truth of this observation as applied to man, if one reviews the statistics. We have had two cases in which an internal biliary fistula has existed, one for 19 years and the other for 15 years, without any evidence of alteration of normal health. In the presence of a fistula, the infection could directly enter the gallbladder. The duodenum, however, is relatively free of pathogenic bacteria.

Fliason and Johnson,[1] in a discussion of life expectancy subsequent to cholecystenterostomy, decided that cholecystogastrostomy or cholecystoduodenostomy has a definite place in the relief of common bile duct obstruction. Yet, they stress the point that the danger of ascending infection is so great as to preclude the adoption of the operation without careful deliberation. While the danger seems established in dogs, Robinson[15] reports such anastomoses in both man and animals without resultant infection. It is known that man frequently survives for many years after such operations.

We wish to record two cases which have survived gallstone obstruction of the bowel, and lived with an internal biliary fistula, for 15 and 19 years, respectively, in normal health. In addition, there are two others with autopsy

findings, which occurred on the service of two confreres on the staff of St. Vincent's Hospital. In all four of these cases the fistula was from the gall-bladder to the duodenum. In each instance, the obstruction was within two feet of the ileocecal valve. The two fatal cases were admitted to the hospital six and seven days, respectively, after the onset of symptoms of obstruction. One reported having had stercoraceous vomiting four days before admission; she was considered too weak to warrant operation, notwithstanding which she survived for five days. The second was operated upon immediately after entering the hospital; she died in shock four hours after operation. There seems to be a similarity in the histories in nearly all cases studied. A detailed report of the symptoms in one case may assist in arriving at an earlier diagnosis.

**Case Report.**—J. B., white, female, age 61, married, weight 170 lbs., was admitted to the hospital, May 11, 1918, with a history of complete obstruction of the bowel of 48

FIG. 1. FIG. 2.

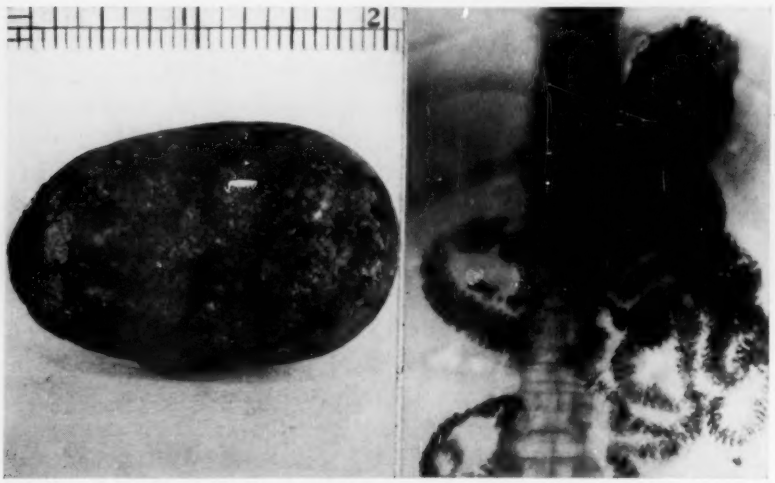

FIG. 1.—Photograph of the gallstone causing the intestinal obstruction.
FIG. 2.—Roentgenogram of the gastro-intestinal tract showing diverticula at the site of attachment of the gallbladder to the duodenum.

hours' duration. Her previous history developed the fact that at the age of 16, she had had an attack of stomach trouble, evidenced by epigastric pain, nausea and vomiting, and had later become jaundiced. She had been constipated all her life, requiring laxatives; has three children; no genito-urinary diseases. For a period of years, she had been treated for episodes of "indigestion with severe headaches, nausea, vomiting and epigastric pain, lasting from one to three days"; and always accompanied by abdominal distention and eructations. The last attack had occurred May 11, 1918, eight days before admission. The onset was not acute. There had been some distress in the epigastric region and she felt very feverish, was nauseated and had frequent vomiting spells. Headache was severe. Two days after the onset, pain in the upper abdomen to the left of the midline developed, and she had some fever and chilly sensations. The pain became intense on the third day, shooting from the epigastrium through to the back in the upper lumbar and interscapular regions. The abdomen had become distended and only small amounts of gas and feces could be passed. During the next few days nothing was passed per rectum, the pain

continued to be very severe and vomiting frequent. The patient became markedly distended and finally fecal vomiting ensued.

*Physical Examination.*—On the eighth day after onset, the patient was in very poor condition and markedly dehydrated. Temperature 103° F., pulse rapid and weak. Face, chest and upper part of the abdomen of mottled purplish hue, while the lower extremities were cold and white. The abdomen was distended and the breathing was rapid but not labored. On palpation, a general soreness of the abdomen was elicited, with acute tenderness in the right lower quadrant. Otherwise, the physical examination was negative.

*Laboratory Data.*—The urine showed a moderate amount of albumin and hyaline casts. The blood showed red blood cells, 3,600,000; hemoglobin, 70 per cent; white blood cells, 12,000, 90 per cent segmented forms; 8 per cent small lymphocytes, and 2 per cent large mononuclear. Wassermann test, negative. The blood picture was almost identical in all of the four cases reviewed here.

*Operation.*—May 19, 1918: Under general anesthesia, the abdomen was opened through a six-inch paramedian muscle splitting incision.

*Operative Pathology.*—The small intestines were greatly distended. The obstruction was found to be situated in the ileum, 12 inches from the ileocecal valve, and had resulted from the impaction of a large gallstone (Fig. 1). The stone was removed and the intestine sutured. Further exploration showed a cobweb-like fibrosis or hepatitis of the right lobe of the liver, in the region of the gallbladder. The gallbladder was firmly attached, throughout its length, to the duodenum, and an opening between the gallbladder and the duodenum, about one and one-half inches in length, was identified. It felt much like the stoma produced by a gastro-enterostomy. A single cigarette drain was inserted. A blood transfusion of 500 cc. was given and normal saline administered subcutaneously, repeatedly, to restore the chlorides. Convalescence was uneventful after the first 24 hours. The patient is still alive after 19 years and still has her biliary fistula, as was recently shown roentgenologically (Figs. 2 and 3). She remains quite asymptomatic.

FIG. 3.—Roentgenogram after administration of dye in order to visualize the gallbladder. Seepage of the dye can be seen passing through the fistula into the duodenum.

## CONCLUSIONS

All cases exhibiting severe abdominal pains, persistent vomiting and localized tenderness with moderate leukocytosis, will be in less danger from an exploratory celiotomy, despite negative roentgenologic findings, than by the expectant type of treatment. If a biliary fistula is found, it need not cause too much concern.

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# CHOLEDOCHUS CYST WITH A DOUBLE COMMON BILE DUCT*

## SEQUELAE AND COMPLICATIONS

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CERTAIN prognostications as to future physiologic reactions were made in 1935, when Doctor Swartley and I[1] reported a case of choledochus cyst with a double common bile duct. It is important to establish by direct evidence physiologic and surgical principles. In this way we are able to go forward with confidence in developing surgical procedures. The realization of these prognostications and certain interesting complications have prompted the present communication.

For those who may not be familiar with this interesting case, it might be well to review the important features, and again state our prognostications.

**Résumé of Case Report.**[1]—D. M., male, age 4, was admitted to the Germantown Hospital in December, 1932. He was operated upon December 13, 1932, at which time a choledochus cyst was found and, after searching, what appeared to be a duct running from the porta hepatis to the duodenum. It was thought this duct was patulous, and would probably be adequate to carry sufficient bile to sustain life. Excision of the choledochus cyst was, therefore, performed. Because of the shocked condition of the patient, it was not possible to definitely establish the arrangement of the ducts. We felt rather certain, however, that they were arranged as shown in Figure 1 (B).

It seemed the right and left hepatic ducts were separate, and did not join, as is normal, but proceeded separately to the duodenum; and that the choledochus cyst and gallbladder were a part of the right hepatic duct, the distal end emptying into the duodenum which, I believe, was not patulous. This duct was ligated on both sides of the cyst.

We prognosticated then that: (1) If the duct to the choledochus cyst was the right hepatic and it was ligated, atrophy of the right half of the liver must follow; bearing out the principle when the need for function ceases, function will cease and the part will undergo atrophy of disuse. (2) If atrophy of the right half of the liver occurs, then there should be a compensatory hypertrophy of the left half of the liver. (3) Compensatory hypertrophy of the left half of the liver will only occur if the left hepatic duct is sufficiently large to adequately take care of the increased secretion of bile. All of these conditions have come to pass. The patency and adequate size of the duct have been demonstrated, by the fact that, since a month after operation until the present time, there has never been any suggestion of jaundice. Atrophy of the right half of the liver and compensatory hyper-

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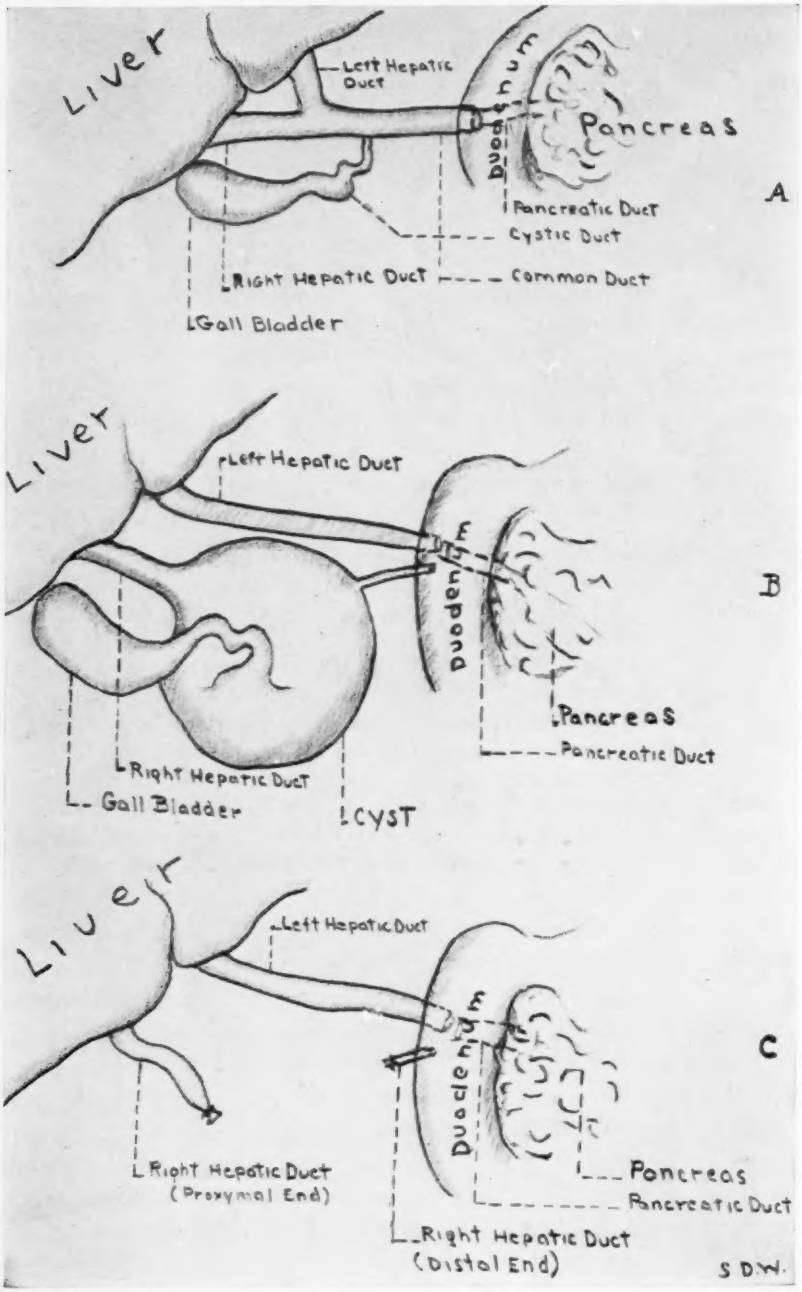


FIG. 1.—Diagrammatic sketches showing: (A) Normal arrangement of bile passages. (B) Present case of double common duct with choledochus cyst before operation. (C) Resultant postoperative anatomy.

trophy of the left half were demonstrated at the time of a subsequent operation, in 1936, when the abdomen was again opened.

*Subsequent Course.*—The patient remained entirely well until January 1, 1936, when he complained of malaise, some generalized pain and distention of the abdomen. The physical examination was negative except for pallor of the skin, a murmur at the apex of the heart, pulse 128, considerable enlargement of the veins of the abdomen and some ascites. Two masses were palpable, one, extending three fingers' breadth below the ensiform, the other, about two and one-half fingers' breadth below the left costal margin. One was thought to be the liver, the other the spleen.

*Laboratory Data.*—Red blood cells, 1,400,000; Hb., 15 per cent; white blood cells, 4,000; thrombocytes, 74,000. All the white blood cells were normal in size, shape and staining. The red blood cells showed polychromasia; there were occasional nucleated cells but the majority were pessary cells, some microcytes and poikilocytosis. There was no stippling.

The coagulation time was five minutes, bleeding time, four minutes; fragility began at 0.3 per cent, not complete in 0.5 per cent. Van den Bergh test: Delayed positive direct reaction, indirect 1.8 units, strength of bilirubin, 9.8 mg. per liter. Sedimentation rate, 38 Mm. in 60 minutes. The stool was weakly positive for blood.

*Treatment.*—Ten transfusions by the direct method were given between January 3, 1936, and February 3, 1936, with very slight improvement in any of the blood elements. On the latter date, there were red blood cells 2,300,000, Hb. 26 per cent, white blood cells 3,900, thrombocytes 82,000. A diagnosis of splenic anemia was made and a splenectomy was performed, February 5, 1936.

The opportunity was offered at this time to verify our previous prognostications. The right lobe of the liver was atrophied, the left lobe greatly hypertrophied. There was a moderate amount of cirrhosis of the liver. The bile duct was visualized in the gastrohepatic omentum passing from the porta hepatis to the duodenum. There was some increase of peritoneal fluid. The veins of the peritoneum and the omentum were greatly enlarged. The spleen filled the left half of the abdomen. It was removed without difficulty, and a blood transfusion of 150 cc. given.

*Pathologic Examination.*—The spleen showed "advanced chronic splenitis with endarteritis and almost complete obliteration of arterioles. Moderate obliterating thrombophlebitis. Almost complete obliteration of splenic architecture. It measures 145x110x56 Mm. The capsule is smooth, the notch prominent. It is a mottled brownish-red, there are areas of dusky purple. The pulp is firm and the splenic follicles are prominent; here and there are small pin point hemorrhages."

*Subsequent Course.*—The patient's convalescence was uneventful excepting that, by April 10, 1936, we were suspicious that he might be developing leukemia, because of a lymphadenopathy and a white cell count that reached 31,000. However, with the aid of two more transfusions and some hypodermic injections of liver, he was discharged with a rather fair blood count—red blood cells 3,800,000, white blood cells 14,900, Hb. 69 per cent, thrombocytes 700,000 (May 3, 1936).

Many blood counts were made during the following year, which showed variations occurring mostly in the white cells. The white blood cell counts were always above 14,000 and on two occasions reached 26,000, with a drop in the neutrophils to 25 per cent, an increase in the lymphocytes to 66 per cent and an increase of eosinophils to 5 per cent. The thrombocyte counts were very high, ranging from 500,000 to 800,000.

The child was otherwise well, attended school regularly and played as other children until September 23, 1937, when he complained of great fatigue and nausea, and vomited a large amount of bright red blood. He vomited blood again, September 25, 1937, and was readmitted to the hospital. Examination showed the skin pale; there was restlessness, and he was apparently very sick. There was abdominal distention and tenderness in the upper abdomen. Blood count: red blood cells 750,000, Hb. 22 per cent, white blood cells 27,500, neutrophils 77 per cent, lymphocytes 17 per cent, mononuclears 6 per cent, marked anisocytosis, many macrocytes and microcytes, some nucleated red blood cells and polychromasia. Five transfusions, by the direct method, were given.

After the bleeding had been stopped for some time, a gastro-intestinal series "showed a large stomach with no filling defect; duodenal cap does not fill out well on the serial films. Considerable amount of barium in the small bowel at the one-hour examination, and a normal duodenal cap. Small six-hour retention with normal duodenal cap." Twenty-four-hour examination showed the barium in the cecum, transverse colon and sigmoid, which appeared stringy.

The greatest amount of free hydrochloric acid (5) was found in the second specimen. The highest total acidity (26) was found in the fifth specimen. Occult blood was weakly positive, negative for bile and starch. The stool was strongly positive for blood. Coagulation time was four minutes; bleeding time five minutes and venous clotting time six minutes.

His convalescence was fairly smooth, and he was discharged November 11, 1937. Blood count: red blood cells 3,005,000, Hb. 42 per cent, white blood cells 16,700, thrombocytes 198,000, reticulocyte count of less than 1 per cent.

Since his discharge he has steadily improved. There has been no evidence of gastro-intestinal or other bleeding, and his blood count December 3, 1937, was: red blood cells 4,350,000, Hb. 59 per cent, white blood cells 17,900, neutrophils 64 per cent, lymphocytes 30 per cent, mononuclears 6 per cent, thrombocytes 920,000. On February 7, 1938, it showed: red blood cells 3,950,000, Hb. 63 per cent, white blood cells 10,100, polymorphonuclears 48, lymphocytes 37, mononuclears 12, eosinophils 2, basophils 1 per cent.

In conclusion, certain questions are raised for which we have not the answers. It is interesting, however, to speculate on them. Are these complications—the blood dyscrasia and the gastro-intestinal hemorrhage—both the result of back pressure on the portal system, resulting from the atrophy of the right half of the liver and the fibrosis in the remaining part? Has the back pressure produced changes in the normal physiology of the spleen, resulting in alterations in function of the reticulo-endothelial system? If this be so, does Banti's disease originate in the liver, and is it the result of changes in that organ produced by toxins, either infectious, metabolic or disturbed endocrine secretions?

We have been inclined to believe the hemorrhage originated in either varicose veins of the stomach or esophagus.

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DISCUSSION.—DR. ALLEN O. WHIPPLE (New York): Doctor Weeder has presented a most unusual and interesting patient. First, the anomaly described is unique. In Kehr's[1] Textbook on Biliary Surgery and Schachner's[2] article describing the collected anomalies of the gallbladder and ducts,

in which he summarizes Kehr's studies, there is no mention of a double common bile duct.

Schachner collected 76 anomalies of the biliary tract, of which 14, or 18 per cent, were multiple. Of these 76 cases, eight showed anomalies of the bile passages. There were two cases of double cystic duct, five with anomalous arrangement of the hepatic duct, and one case of absence of the common duct in an infant.

There is no doubt that far more of these anomalies are seen than those reported in the literature. Every surgeon of experience in biliary tract surgery has seen them. It is important to emphasize the point of adequate exposure for visualization of the gallbladder and gastrohepatic omentum. If an anomaly of the blood supply to the gallbladder is found, an anomaly in the duct arrangement should be looked for and vice versa.

The second point, and to the speaker even more interesting, is the subsequent history of this case, with the development of a splenomegaly in the presence of a cirrhosis with portal bed obstruction. We have been greatly interested in our Combined Spleen Clinic, at the Presbyterian Hospital, in the pathogenesis of splenomegaly. In some patients, undoubtedly intrahepatic portal obstruction results in a splenomegaly. In other cases, with thrombophlebitis of the splenic or portal vein proximal to the liver, splenomegaly develops without liver changes. In still others, portal bed irritation, as seen in schistosomiasis and in dogs following silica powder injections of a portal radical, splenomegaly is associated with cirrhosis. In all of these several pathogeneses, the clinical picture is Banti's syndrome, *i.e.*, an anemia, a leukopenia, a low platelet count and an enlarged spleen.

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Dr. S. Dana Weeder (closing): We drew the conclusions in the first paper on this subject that probably there were more cases of double ducts in association with choledochus cyst; that a search should be made for a duct running through the gastrohepatic omentum, and if it be found and thought to be patulous, then removal of the choledochus cyst should be undertaken. This would result in a lowering of the present mortality of 28 per cent resulting from choledochocystoduodenostomy.

# DOUBLE GALLBLADDER WITH TWO CYSTIC DUCTS AND TWO CYSTIC ARTERIES

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WHILE variation from the usual distribution of the biliary ducts is common, duplication of the gallbladder is relatively rare, occurring about once in every 3,000 to 4,000 human beings. A satisfactory embryologic explanation of these anomalies in man is difficult or impossible.

Boyden,[1] in 1926, undertook an investigation in order to ascertain the comparative and embryologic background for the comparison of human anomalies of the biliary system. In his study of comparative anatomy, 10,000 autopsies were performed upon domestic animals (Table I).

TABLE I

STUDY OF COMPARATIVE ANATOMY OF 10,000 AUTOPSIES PERFORMED UPON DOMESTIC ANIMALS SHOWING ANOMALIES OF THE GALLBLADDER

| Animals | Number | Anomalies | Per Cent |
|---|---|---|---|
| Cats | 2,568 | 315 | 12.0 |
| Calves | 2,555 | 95 | 3.5 |
| Sheep | 2,560 | 30 | 1.17 |
| Pigs | 2,572 | 13 | .5 |

In man, however, Boyden found that data regarding gallbladder anomalies revealed a startling infrequency. Inquiries sent to 11 of the largest hospitals showed but one anomaly among 9,221 autopsies. A request for case reports from roentgenologists revealed only three anomalies. Thus, 19,191 examinations showed only four anomalies. Searching the literature, he found 15 case reports of accessory gallbladders, to which he added five other instances which had not been reported, making a total, up to 1926, of 20 cases of double gallbladder with two cystic ducts. Of these cases, four had separate ducts, which later united into a common canal before entering the common duct, and nine cases could not be classified regarding the arrangement of the ducts. The remaining three case reports were of the bilobed gallbladder variety and were: (1) A drawing in Cruveilhier's Anatomy, 1864, showing an anomaly but not accompanied by any history; (2) a case reported by Deaver and Ashhurst, 1914, stating that the specimen was "bilobed," one large lobe discolored and gangrenous and containing one calculus, the other lobe normal, and (3) a case reported by Ullman, which had been diagnosed by cholecystography, but which on exploratory operation failed to reveal more than one cystic duct. Therefore, from 1674 to 1926, reports of only 20 cases of double gallbladder are to be found in the literature.

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Slaughter and Trout,[5] in 1933, reviewed the literature in an abbreviated manner, including Boyden's article, and found 11 other case reports of double gallbladder and added a case of their own. This was of a female, age 32, who, at operation, was found to have the cystic duct adherent to the duodenum. The gallbladder contained no calculi. After removal of the gallbladder, a second gallbladder, 5x1 cm. in diameter, was found in the liver substance with a separate duct leading from it. This second gallbladder appeared atrophic but was otherwise normal; it was, therefore, not removed. Later the patient was given dye but the remaining gallbladder could not be visualized.

This list of 12 cases, in addition to the 20 cases reported by Boyden, made 32 cases of anomalies of the gallbladder reported up to March, 1933. The entire series of cases reported by Slaughter and Trout was composed of double gallbladders.

Weiss,[6] in 1935, reported three cases of double gallbladder diagnosed by cholecystography, two with calculi. He pointed out that in order to be included under the classification of double gallbladder, each gallbladder should have its own cystic duct, thus differentiating it from the bifid gallbladder, in which the cavities are distinctly separate but communicate with the common duct through a single cystic duct. He modified Boyden's classification of the aberrant hepatic vesicles, and placed them into the following four groups:

(1) *Ductular.*—Derived from supernumerary vesicles from either the hepatic, cystic, or common bile ducts. Two cavities are present, each having its own cystic duct. This type is found chiefly in man but is present also in cats.

(2) *Bilobed.*—Formed by initial subdivision of the primitive gallbladder bud. Two cavities communicate with the common bile duct through a single cystic duct. This type is found chiefly in cats but is also found in man.

(3) *Diverticular.*—Resulting from persistence of cavities and septa in the gallbladder bud. One large cavity, communicating with one or more smaller cavities, found chiefly in ungulates.

(4) *Trabecular.*—A vesicular outgrowth of liver trabeculae, common in cattle and sheep, but of doubtful occurrence in humans.

Gross,[3] in 1936, reviewed the literature and found 147 cases of congenital anomalies of the gallbladder and reported a case of double gallbladder found at the autopsy of a child, age three years and three months. At no time during the patient's life had there been symptoms of disease of the biliary tract. One of the accessory gallbladders was found in the substance of the liver and its duct communicated with the midportion of the main hepatic duct. The other, or primary gallbladder, was on the undersurface of the liver and its duct entered the common duct at the junction of the hepatic and common ducts. Both cystic ducts were present.

Therefore, with the 20 cases of double gallbladder reported by Boyden, the 12 reported by Slaughter and Trout, the three reported by Weiss, and one by Gross, there had been 36 cases reported up to January, 1936.

A case of double gallbladder with two cystic ducts, found at operation,

is herewith presented. It is interesting not only because of the anomaly, but because of the several types of gallbladder disease present in the specimen removed.

**Case Report.**—Hosp. No. 17525: B. W., white, female, married, age 55, was admitted to the Jamestown General Hospital, December 14, 1936, complaining of severe epigastric pain associated with nausea and vomiting. She stated that about 2 A.M. she was awakened by severe epigastric cramp-like pain radiating to between the scapulae and associated with nausea and vomiting. Since its onset, the pain had gotten steadily worse and was not relieved by a hypodermic of morphine. She had had repeated attacks of similar pain, although not so severe, during the past 20 years. During the past year,

FIG. 1. FIG. 2.

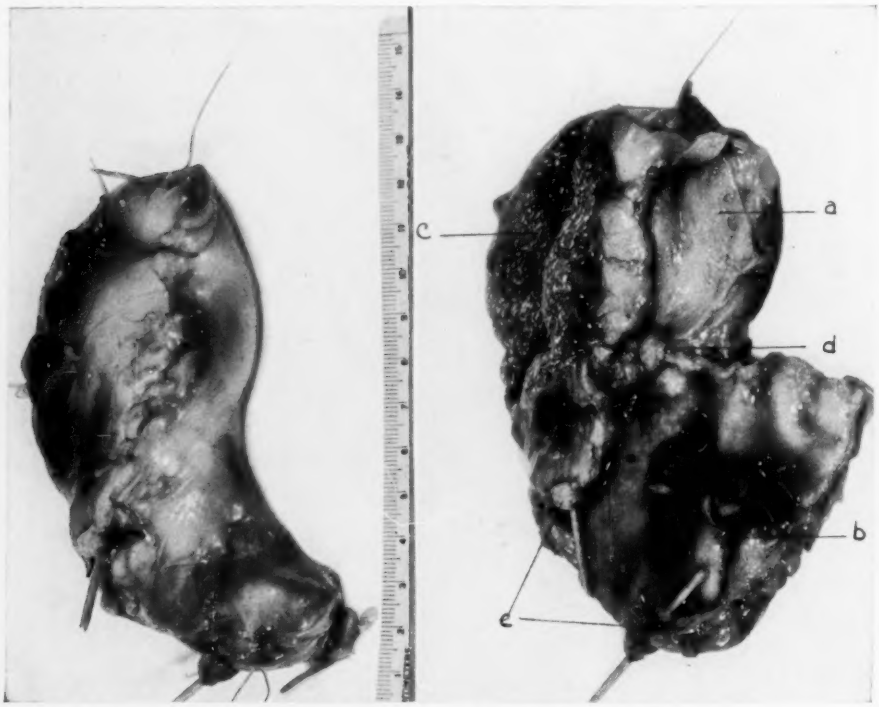


FIG. 1.—Photograph of the unopened specimen. Wooden probes in cystic ducts.
FIG. 2.—Photograph of the open specimen, with lettering corresponding to Figure 3: (a) Empyema cavity; (b) cavity containing five gallstones; (c) "strawberry" gallbladder; (d) thick septum of fibrous tissue separating empyema cavity (a) from cavity containing gallstones (b); (e) cystic ducts. The pale, smooth lining of cavities (a) and (b) shows the effect of the chronic inflammation, and their thick, edematous walls is evidence of the acute inflammation.

these attacks had become more frequent and more severe. The last one, two months previous to admission, lasted four days, during which she was treated with morphine. She had never been jaundiced. She had noticed that fatty or greasy foods caused her indigestion.

Except for repeated attacks of epigastric pain her past history was irrelevant. She had had six pregnancies, none of which was associated with pain similar to that of her present illness. She had gained 25 pounds in weight during the past year and had noticed some shortness of breath on exertion and swelling of the ankles.

*Physical Examination* revealed an acutely ill, very cooperative, short, obese, white female, five feet, four inches tall; weighing 214 pounds. Temperature 98.2° F.; pulse 82;

blood pressure 150/82. There was no jaundice. The abdomen was thick-walled and pendulous. There was muscle spasm and acute tenderness to pressure just to the right of the midepigastrium. No masses were palpated.

*Laboratory Data.*—Urine: clear, straw colored, sp. gr. 1,020, very faint trace of albumin, sugar negative; microscopic examination showed few pus cells. W.B.C., 16,400; polymorphonuclears, 85 per cent; lymphocytes, 10 per cent; large mononuclears, 5 per cent. *Clinical Diagnosis.*—Acute cholecystitis and obesity.

The patient was given 1,000 cc. of 5 per cent glucose by hypodermoclysis and morphine to control the pain. The following day, 36 hours after the onset of the attack of pain, she was operated upon.

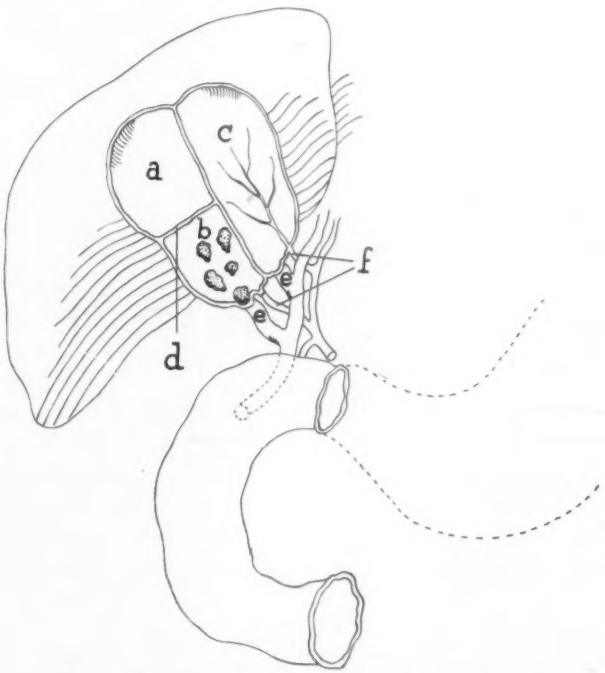


FIG. 3.—Diagrammatic drawing of specimen removed: (a) Empyema cavity; (b) acutely inflamed cavity containing gallstones, corresponding to the pouch of Hartmann; (c) second gallbladder, separated from the first by a common wall, seat of cholesterosis; (d) septum of chronic inflammatory tissue separating empyema cavity (a) from acutely inflamed cavity containing stones (b); (e) cystic ducts; (f) cystic arteries.

*Operation and Operative Pathology.*—Doctor Wilson: Under nitrous oxide-ether anesthesia the abdomen was opened through a right transverse subcostal incision. On opening the peritoneal cavity a large gallbladder presented itself, resembling a markedly dilated and thickened small intestine in color and appearance. The omentum was adherent to the anterior surface. The portion nearest the duodenum was acutely inflamed and the entire gallbladder was thickened. The pouch of Hartmann resembled, and was about the size of the average gallbladder.

Dissection was started from above downward, stripping the gall bladder from the liver bed, leaving enough peritoneum to cover the raw surface. Leading into the gallbladder below the pouch of Hartmann was a cystic duct, accompanied by a cystic artery. A stone was impacted in this cystic duct; this was milked into the gallbladder and the duct and artery were clamped, divided, and ligated separately. On dissecting back along

FIG. 4. FIG. 5.

FIG. 4.—Photomicrograph of section taken from empyema cavity (Figs. 2a and 3a) showing obliteration of glandular mucosa together with a marked inflammatory reaction in subcutaneous area.
FIG. 5.—Photomicrograph of section taken from the acutely inflamed cavity (Figs. 2b and 3b) showing acute inflammation in the submucous area extending down into the muscle.

FIG. 6. FIG. 7.

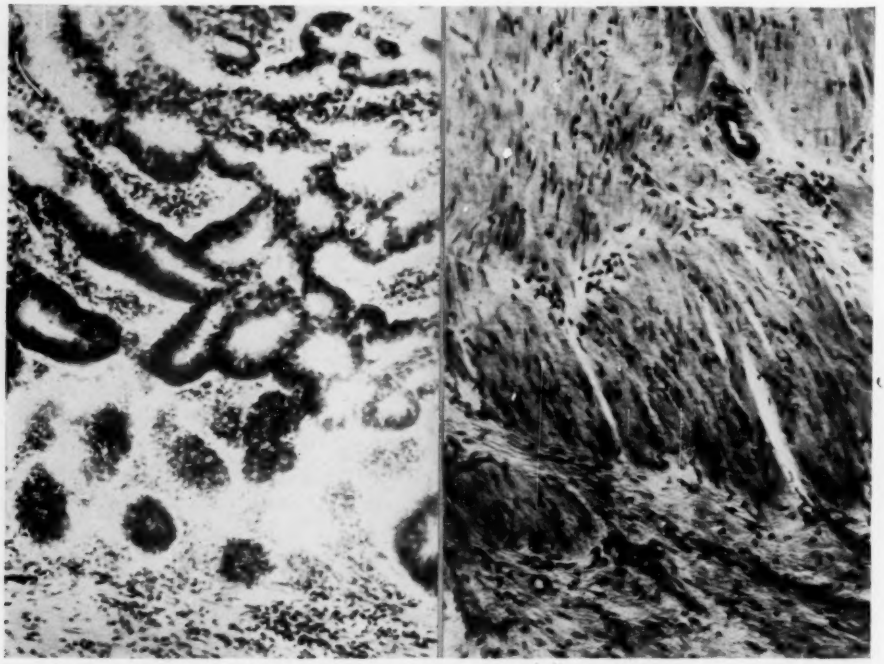

FIG. 6.—Photomicrograph of section taken from cavity (Figs. 2c and 3c) showing proliferation of glands showing papillomatous growth. Grossly, the mucosa was covered by deposits of cholesterol, giving it the appearance of a typical "strawberry" gallbladder.
FIG. 7.—Photomicrograph showing leukocytic infiltration of the muscular coat.

the common duct toward the liver, a second cystic duct and artery were discovered, about 2.5 cm. from the first one. This duct was normal in appearance and size. It, and the accompanying artery, were separately clamped, divided, and ligated, after which the gallbladder was removed. There was a large acutely inflamed lymph node at the junction of the second cystic duct with the common duct. Peritoneum was sutured over the raw liver bed; a cigarette drain was placed to the foramen of Winslow, and the incision was closed in layers about it, and a small rubber tissue drain introduced into the median angle of the incision.

*Pathologic Examination.—Gross:* On opening the gallbladder it was found to be divided by a longitudinal septum into two distinct cavities, with the septum as a common wall for each organ, each cavity having a separate duct and artery supply.

The part of the gallbladder corresponding to the pouch of Hartmann (Figs. 2b and 3b) contained five facetted calcium-bilirubin calculi varying in size from 0.7 to 1 cm. in diameter. This cavity contained about 30 cc. of black bile, in which were flecks of pus; it was supplied by a cystic duct and accompanying artery. Separating this cavity from a similar one (Figs. 2a and 3a) was a septum of tough fibrous tissue (Figs. 2d and 3d). This second cavity contained about 30 cc. of thick, gray pus and its walls were thickened and inflamed. The cystic duct nearest to the liver led into a third cavity (Figs. 2c and 3c) separated from the distal side by a common wall. Its walls were moderately thickened, though not nearly as much as those of the other two cavities. It had a bluish-gray appearance from the outside. About 40 cc. of thick, black bile was removed. On the soft mucosal surface there were areas of cholesterol deposits which gave this part of the gallbladder a typical "strawberry" appearance. The specimen measured 11.7 by 4.8 cm. in diameter. The entire gross specimen was sent to the State Institute for the Study of Malignant Disease, Buffalo, N. Y., for microscopic examination.

*Microscopic Examination.*—Dr. A. A. Thibideau. "Sections of the gallbladder wall taken at various areas show an acute inflammatory reaction extending throughout the wall. In some areas there is a marked papillary proliferation of the glandular epithelium lining the gallbladder. There is some question as to the presence of malignant changes in these areas as the proliferation extends into the lumen of the gallbladder and apparently does not invade the gallbladder wall proper. *Pathologic Diagnosis.*—Acute cholecystitis and papilloma of the gallbladder."

*Postoperative Course.*—The patient made an uneventful recovery from the operation. At no time was her temperature above 100° F. She was discharged on the fifteenth day postoperative.

COMMENT.—It is to be regretted that no roentgenologic examination of this double gallbladder was made. The patient had not been seen by the author before the last attack of pain for which she sought relief, and no roentgenograms had been taken prior to that attack. It is the author's practice to treat acute cholecystitis by early operation, believing that such a procedure avoids much suffering, prevents liver damage, and is less dangerous. Certainly, the patient is better off following an operation which is preceded by only a short period of illness, of a few hours' duration, than she would be if forced through a period of fever, pain, nausea, vomiting, with restricted food intake and the other discomforts of "the cooling off" process.

## SUMMARY

(1) A brief review of the literature on double gallbladder is presented, there having been 36 cases reported up to the present time, indicating the rarity of this anomaly in man.

(2) A case of double gallbladder with two cystic ducts and two cystic arteries is presented. The gross pathologic examination shows the five stages of gallbladder disease: (1) Acute cholecystitis; (2) chronic cholecystitis; (3) cholelithiasis; (4) cholesterosis; and (5) empyema. The microscopic examination showed, in addition, a papilloma of the gallbladder.

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# THE EFFECT OF DEHYDROCHOLIC ACID UPON BILIARY PRESSURE AND ITS CLINICAL APPLICATION

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Following cholecystectomy in some instances, symptoms develop which are referable to partial obstruction of the common duct, either by a calculus overlooked at the time of operation or by a mucous plug, blood clot or inspissated bile. In the past it has been necessary on many occasions to reoperate upon the patient to relieve such an obstruction, but during the last 18 months, we have been carrying out studies on the cholangiographic demonstration of such obstructing agents and a nonoperative method of removing them.

Fundamentally, the method we have used consists in increasing the pressure behind the foreign body and relaxing the sphincter area in front of it, thereby permitting the object to pass out of the duct and into the duodenum, unless it is a stone of too large a caliber. There are two methods of increasing the pressure behind the obstructing agent. One, depends upon the presence of a T-tube or catheter in the common duct and consists in irrigating the duct with sterile normal saline or other solutions, using a syringe to increase the pressure. The other method depends upon an increased flow of bile at an increased pressure in response to a choleretic drug such as dehydrocholic acid.

The latter method has the distinct advantage that a fistula or drainage tube is not necessary, and it may, therefore, not only be applied as a therapeutic measure in all cases postoperatively, but may be used as an added step in the routine nonoperative management of gallbladder disease. By employing dehydrocholic acid, the pressure may be exerted more or less continuously over a given period and at any momentary relaxation of the sphincter, autonomically or through the use of drugs, the foreign body may escape from the duct.

Oddi,[17] in 1894, attempted to discover what pressure the sphincter might withstand without relaxing or "breaking" open. He found this to be 675 Mm. of water. Heidenhain and Friedlander disputed his finding and describe a pressure of 200 Mm. In 1926, Potter and Mann[18] summarized the observations of many workers on the pressure withstood by the sphincter of Oddi in various animals (Table I). The average pressure found by these workers seems to rest between 100 and 150 Mm. of water. It is difficult to correlate Oddi's finding with those of the other authors.

Koster and Shapiro,[11] in 1936, devised a manometer to determine the pressure withstood by the sphincter of Oddi, which they found to be 230 Mm. of

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water. Their base line was determined by actually measuring the depth of the common duct below the skin surface.

TABLE I

SUMMARY OF OBSERVATIONS ON BILIARY PRESSURE

(*Potter and Mann*[18])

| Observer | Animal | Pressure in Millimeters |
|---|---|---|
| Oddi | Dog | 675 |
| Archibald | Dog | 180–330 |
| Judd and Mann | Dog | 100–150 |
| Mann | Cat, dog, goat, rabbit, guinea-pig | 75–100 |
| | Gopher rat | 30 |
| Jacobson and Gydesen | Dog | 150 |
| McWhorter | Dog | 100–200 |
| Cole | Dog | 150 |
| Winkelstein and Aschner | Dog | 60– 65 |

Mann[13] was curious as to what relationship might exist between the presence or absence of a gallbladder and the sphincter tone. He, therefore, made a series of pressure studies in animals normally having a gallbladder and another series in animals normally lacking this organ. In the former group, fell the dog, cat, goat, rabbit, striped gopher and guinea-pig. The sphincter resistance in these animals was found to average 100 Mm. of water. In the second series only one animal was used, the gopher rat. Its resistance was found to be 30 Mm. at the maximum.

Following these studies on the normal pressure required to overcome the tone of the sphincter of Oddi, it developed, naturally, that studies concerning the effect of drugs, foods, and other agents upon the sphincter would be undertaken.

Lueth,[12] in 1931, studied the effect of duodenal peristalsis upon the sphincter "break" pressure. He found that pilocarpine, which caused hypertonus in the duodenum, interfered with relaxation of the sphincter and brought about an increase in the "break" pressure from 20 to 60 Mm. of water. He also noted an influx of bile into the duodenum during its relaxation which ceased with active peristalsis.

Potter and Mann,[18] in 1926, found the average duct pressure in the dog to be 120 Mm. of water. They noted that fasting brought about a reduction in this pressure and that milk caused a marked rise. They also commented on the fact that cholecystectomy produced an increase in the common duct pressure to 235 Mm., whereas, Judd and Mann[9] had previously stated, in 1917, that after cholecystectomy the sphincter of Oddi did not have a pressure resistance as high as that previous to operation.

Elman and McMaster,[6] in 1926, claimed to have demonstrated that fasting caused greater resistance to the flow of bile into the intestine, while feeding resulted in lowered resistance to this flow. They determined biliary pres-

sures four to six hours after feedings and determined 100 to 120 Mm. of water to be the normal range, while after fasting, the pressure would range between 150 and 250 Mm. After a meal, pressure often reached as low as 50 Mm. They noted that even the smell of food lowered the resistance to biliary flow. Twenty to 25 minutes after a meal, they observed a "secondary increase" in resistance to bile flow.

McGowan, Butsch and Walters,[14] in 1936, studied the effect of different drugs upon the sphincter of Oddi and the resultant changes in biliary pressure, noting the onset of pain on one occasion with a water column 160 Mm. above the skin surface. They found that after administering morphine the pressure rose from 200 to 350 Mm. of water and that amyl nitrite caused complete disappearance of the pressure and relief from pain.

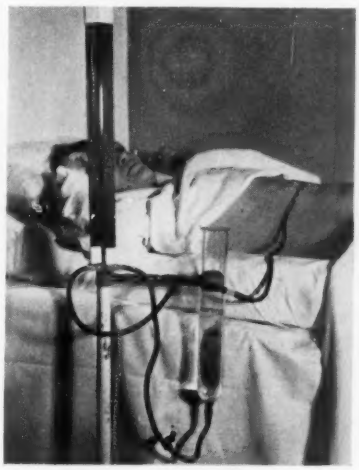


FIG. 1.—The manometric equipment used in determining the pressure within the common duct.

Best and Hicken,[2] in 1935, although not measuring the pressure within the common duct during their cholangiographic studies on spasm of the sphincter, assumed and stated that the pain was due to the increased ductal pressure occasioned by the spastic occlusion of the lower end of the common duct. They presented cholangiograms showing relaxation of the spastic sphincter following administration of 1/100 Gr. of nitroglycerin beneath the tongue.

Koster and Shapiro[10] criticized the readings of McGowan, because the base line used was the skin surface, but so long as the same base line was used each time, the relative change in pressure would be significant.

Doubilet and Colp,[5] in 1937, stated that, in the absence of the gallbladder, meals have no effect upon sphincter tone. They found, however, that duodenal lavage, using a solution of magnesium sulfate, produced a relaxation of the sphincter. Hydrochloric acid placed in the duodenum caused a spasm of the sphincter which could be relieved with atropine. Morphine, however, produced a spasm of the sphincter which persisted over three hours and was not relieved by atropine. This appears logical when one considers the pharmacologic action of atropine, which causes paralysis of the parasympathetic nerve endings, and that morphine directly stimulates the smooth muscle.

Elman and McMaster[7] found that the secretory pressure of the liver is a rather definite entity, above which biliary secretion stops. Herring and Simpson,[8] in 1907, noted the average maximum bile pressure in the dog, cat and monkey as 300 Mm. The highest they recorded was 373 Mm. in a cat. Similarly, McMaster, Brown and Rous,[15] in 1923, stated that bile ceased to be secreted when the duct pressure reached 350 Mm. of bile.

It might be well at this time to clarify the terms "secretory pressure of the

liver," the so-called "normal common duct pressure" and the "break pressure" of the sphincter area. We feel, after reviewing the observations of others, that the secretory pressure varies between 200 and 300 Mm. of water. The pressure within the common duct must necessarily vary with and be dependent upon the amount of bile secreted into the duct with a given liver secretory pressure. This, in turn, must be dependent upon the resistance en-

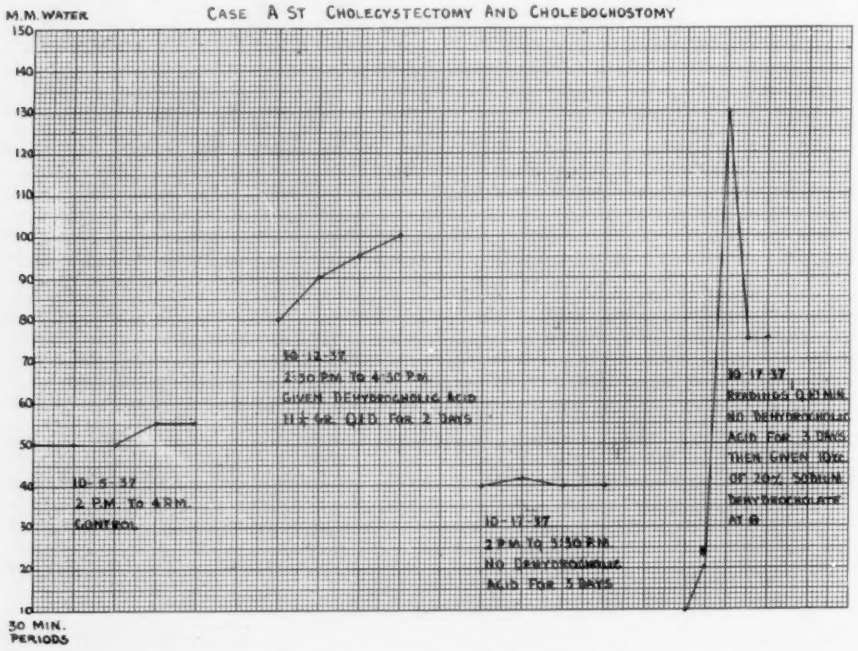



CHART 1.—Case 1: A. S., female, age 58, entered the hospital August 28, 1937, complaining of recurrent R.U.Q. pain radiating to the right shoulder blade of 16 years' duration. These attacks were associated with rather severe indigestion and vomiting. Nineteen years previous to admission, she had had a cholecystostomy after an attack of R.U.Q. pain with jaundice. Graham-Cole studies showed marked impairment of gallbladder function with lithiasis. Cholecystectomy and choledochostomy, with T-tube in the common duct, were performed September 22, 1937. The postoperative cholangiogram was negative. Pressure readings were made over a period of three weeks and typical readings are recorded on Chart 1. The control readings varied between 50 and 55 Mm. of water. After administration of dehydrocholic acid for several days, the level of intraductal pressure was found to vary between 70 and 100 Mm. of water. After discontinuing the drug for three days, the pressure dropped even to below that of the first control period. Intravenous injection of sodium dehydrocholate resulted in a sudden rise of the pressure to 120 Mm., but this exceedingly high pressure was not sustained.

countered at the point of outlet of the bile, which is the sphincter area. The pressure within the duct will build up with the increase in resistance at the sphincter area. The sphincter "breaking pressure" is that reading where the sphincter gives way to the bile pressure behind it. Various pathologic changes or physiologic disturbances may affect the state of tonus of the sphincter.

Herring and Simpson[8] also related that the intravenous injection of bile was invariably attended by increased secretion of bile. They found that an increase in biliary pressure followed unless the pressure at the time of injection was high. They concluded, therefore, that a rapid rate of secretion is not essential to the production of a high pressure but that it influences the form of the pressure curve.

Neubauer,[16] in 1923, injected 3 cc. of 4 per cent sodium dehydrocholate into the vein of a rabbit and found that the pressure increased nearly 20 Mm. within a very few minutes after the injection.

Adlersburg and Neubauer,[1] in 1926, attempted to bring about an increased excretion of foreign substance through the liver by means of sodium dehydrocholate. They found that no increase occurred in the amount of tetrachlorophenolphthalein excreted by the normal liver or by one whose function was deranged following intravenous administration of sodium dehydrocholate.

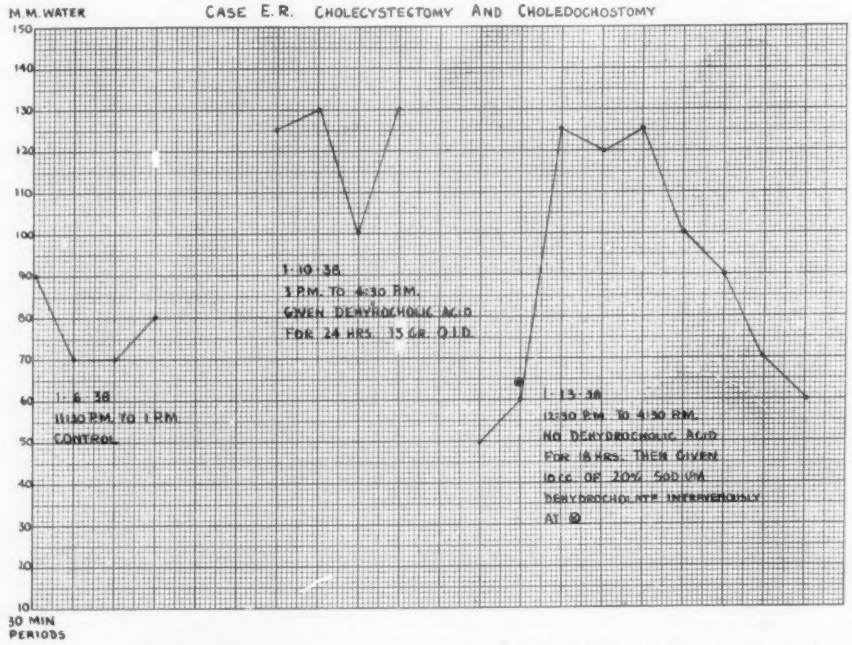



CHART 2.—Case 2: E. R., female, age 22, entered the hospital December 12, 1937, with the history of severe recurrent gallbladder attacks for the past year, requiring hypodermics. No history of jaundice. Physical examination revealed extreme tenderness over the gallbladder. Roentgenograms demonstrated cholelithiasis. Cholecystectomy and choledochostomy were performed December 21, 1937, and three stones were removed from the common duct. A T-tube was placed in the duct. The postoperative cholangiogram, on the eighth day, showed a normal duct with no filling defect. Pressure readings were repeated over a period of time and the control readings varied between 70 and 90 Mm. of water. Following administration of dehydrocholic acid for 24 hours, the pressure level was considerably higher, varying between 160 and 130 Mm. After discontinuing the dehydrocholic acid for 18 hours, 10 cc. of a 20 per cent solution of sodium dehydrocholate were given intravenously. An immediate rise in the pressure to 125 Mm. followed, but was not long sustained.

Wakefield, Powelson and McVicar,[22] in 1929, found sodium dehydrocholate (decholin) to cause an increased flow of bile in patients who had T-tubes in their common ducts following cholecystectomy. This occurred in 18 out of 20 patients studied. They attributed the increase to a dilution of the constituents normally present.

Sterner, Bartle and Lyon,[21] in 1931, analyzed somewhat similar studies which they carried out on 21 patients. They found an average bile flow of 80 cc. per 10-minute period in the series of control readings taken. After

giving 10 cc. of 20 per cent solution of decholin intravenously, there was an increase in this average to 134 cc. per 10-minute period.

Regan and Horrall,[19] in 1932, demonstrated in dogs that the intravenous injection of 2 Gm. of sodium dehydrocholate increased the flow from a biliary fistula within one minute. This effect persisted over periods which varied from two to five hours. By using a common duct manometer, they found that bile pressure was also increased from a previous average of 341 Mm. to an average of 385 Mm. following the injection.

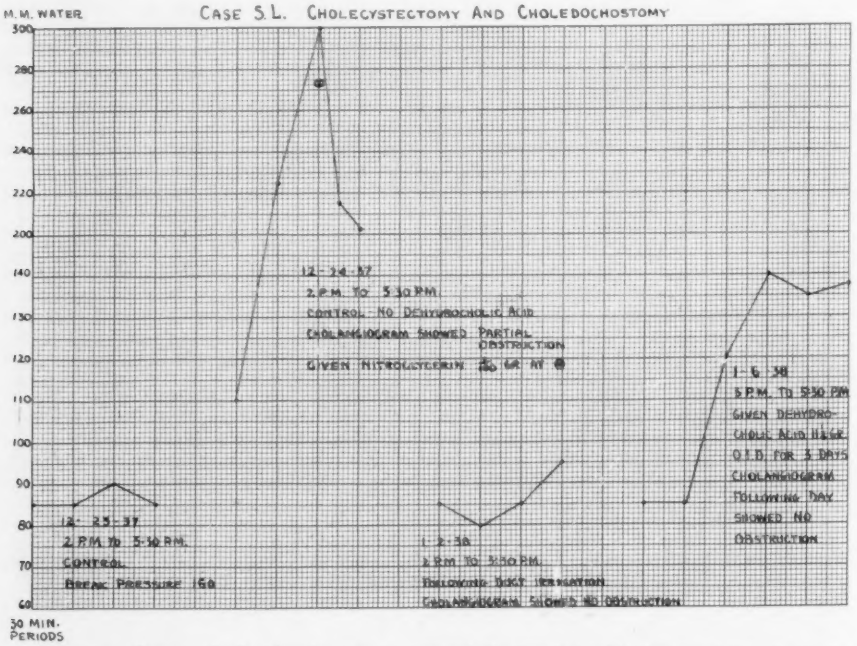



CHART 3.—Case 3: S. L., female, age 53, entered the hospital with the complaint of recurrent attacks of R.U.Q. pain for the past seven months, one being accompanied by jaundice. She suffered bloating and distress in the epigastrium only with the attacks of pain. Laboratory data were negative except for icteric index of 12. Cholecystectomy and choledochostomy were performed December 15, 1937, and a T-tube was placed in the common duct. A cholangiogram, December 24, 1937, showed some apparent obstruction in the common duct. The T-tube was removed January 10, 1938, and drainage ceased January 13, 1938. The control readings, December 23, 1937, varied between 80 and 90 Mm. of water, and the "break" pressure was recorded at 160 Mm. On the following day, another control reading was made, revealing the intraductal pressure to be 300 Mm. of water; and as long as the tube was closed off the patient had severe pain in the R.U.Q., radiating into the back. This was relieved by placing 1/100 Gr. of nitroglycerin under the tongue, and the pressure dropped to 205 Mm. The common duct was irrigated for several days and by January 2, 1938, the pressure had dropped back to between 80 and 100 Mm. A cholangiogram the following day, showed no obstructing agent. Dehydrocholic acid was then given for three days and intraductal pressure readings rose to between 85 and 140 Mm. of water. A cholangiogram, January 7, 1938, again revealed no obstructing agent.

Reinhold and Wilson[20] studied the manner in which dehydrocholic acid produced its "striking choleretic action." They concluded that this effect was accomplished primarily by augmented excretion of water, probably associated with rapid excretion of the dehydrocholic acid itself.

Thus, we found a variety of basic experiments which served to guide our study toward dehydrocholic acid and its sodium salt as a choleretic and "cholepressor," in our attempt to evolve a method of increasing biliary pressure in order to flush débris from the common duct.

*Technic.*—Each patient studied in our series was convalescing from cholecystectomy and choledochostomy. At the time of operation a T-tube had been carefully placed into the common duct and brought out through a separate lateral stab wound in every case, and a delayed cholangiogram had been made between the seventh and tenth postoperative days, to investigate the status of the common duct and the sphincter. Most patients were on the general ward diet during the course of the studies but readings were made at the same time of day, insofar as possible.

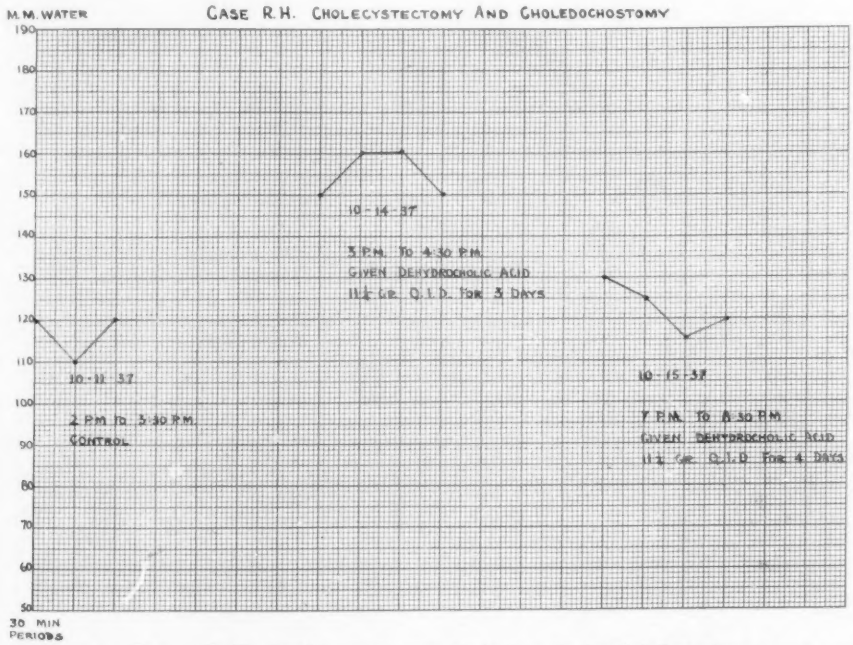



CHART 4.—Case 4: R. H., female, age 52, was admitted to the hospital September 1, 1937, complaining of recurrent attacks of R.U.Q. pain, radiating to the back over a 10-year period. Late attacks had been associated with chills and followed by fever. She had not been definitely jaundiced but stools were light in color and the urine dark. She had some pruritus, and had indigestion between attacks. The icteric index was 21. Roentgenologic examination did not visualize the gallbladder or calculi. Cholecystectomy and choledochostomy were performed September 22, 1937. Postoperative intraductal pressure readings were taken during a period of eight days and the reading, October 11, 1937, is quite typical of the control readings. On October 14, 1937, it shows the increase in intraductal pressure after administration of 11¼ Gr. of dehydrocholic acid q. i. d. for three days. On the following day, although still on dehydrocholic acid, the general level of the intraductal pressure was lower, but was still a little higher than that during the control period. This drop in the intraductal pressure after three to five days' administration of dehydrocholic acid, has occurred rather frequently and is somewhat difficult to interpret, but we are inclined to believe that the increased bile flow may, by increase of pressure, have exhausted the sphincter, or a natural relaxation of the sphincter may follow the administration of this drug over a period of time. The bile output, as we interpret the work of other investigators, does not show a comparative drop.

The manometric equipment consisted of a glass reservoir connected to a glass T-tube, which in turn was connected by one arm to a glass manometer and by the other to a rubber tube which linked the apparatus to the patient's T-tube. The manometer was a straight piece of glass tubing of 2 Mm. bore with a centimeter scale beside it (Fig. 1).

Before carrying out each experiment, the entire apparatus was sterilized and aseptic technic was carefully followed during the procedure. The reservoir

was filled with sterile normal saline solution warmed to body temperature and the entire system carefully freed of air bubbles. After connecting the apparatus with the patient, the zero point of the manometer was adjusted to the apparent level of the common bile duct. The reservoir was then raised slowly until the solution began to flow freely into the biliary tract and the pressure at this point was noted. This we termed the sphincter "break" pressure. When this reading was determined, the reservoir was lowered until the

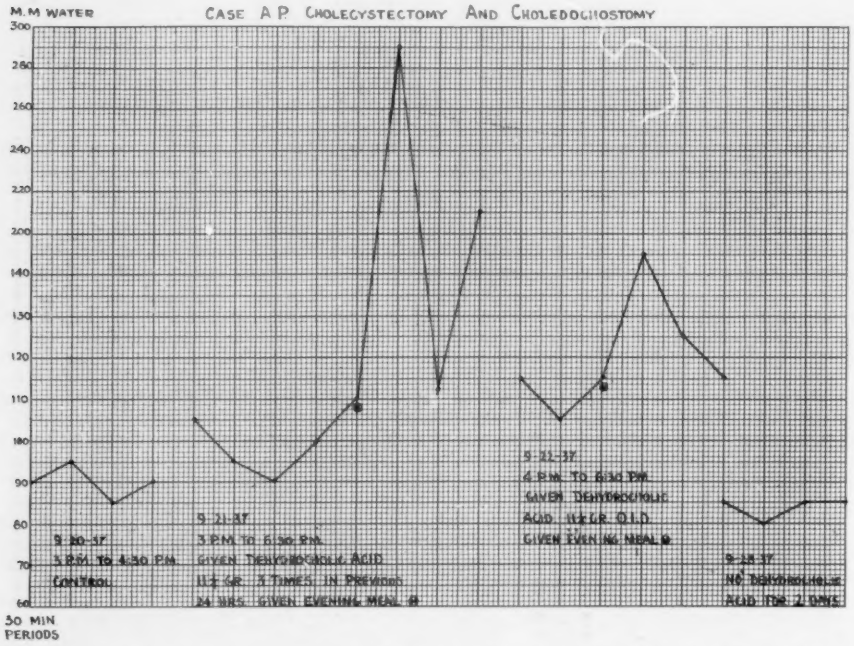
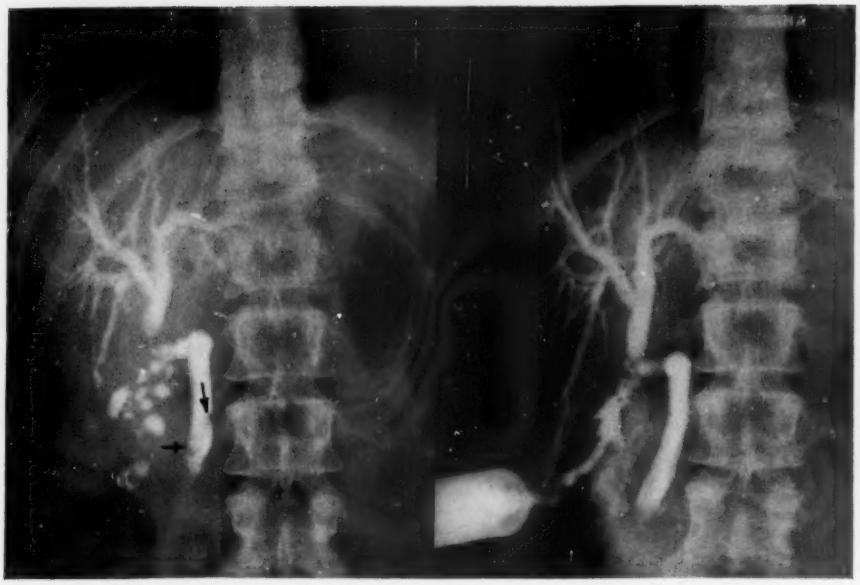



CHART 5.—Case 5: A. P., female, age 58, entered the hospital August 24, 1937, with the history of four attacks of severe R.U.Q. pain, radiating to the back during the last 10 years. These were followed by icterus and pruritus. The last attack occurred one month before admission, and was associated with chills, fever, dark urine and clay colored stools. She had been constipated for years. Her icteric index on admission was 9. Cholecystogram revealed faint concentration of dye suggestive of mild cholecystitis. Cholecystectomy and choledochostomy were performed, September 4, 1937. A cholangiogram, two weeks later, showed all ducts clear. The control intraductal pressure readings were taken on several occasions and were found to vary between 80 and 90 Mm. of water. The control reading of September 20, 1937 is charted. She was given 11¼ Gr. of dehydrocholic acid t. i. d., beginning the morning of September 21, 1937, and the reading for that afternoon is charted. The general level of intraductal pressure is higher. The evening meal, consisting of corn beef hash, cole slaw and chocolate pudding, was served at 5 P.M. and was followed by an immediate rise in intraductal pressure. This has been interpreted as spasm of the sphincter, possibly caused by the rather coarse diet, particularly the salad. On September 22, 1937, the general level of the pressure is higher, and here again, a rapid rise occurs at mealtime, after the ingestion of scalloped corn, bacon, mixed fruit salad and burnt sugar cake. On September 28, 1937, after having had no dehydrocholic acid for two days, we find the intraductal pressure again between 80 and 90 Mm. of water. This phenomenon may be the dramatic representation of what occurs in biliary tract disease, and may explain the distress at mealtimes upon the ingestion of certain foods.

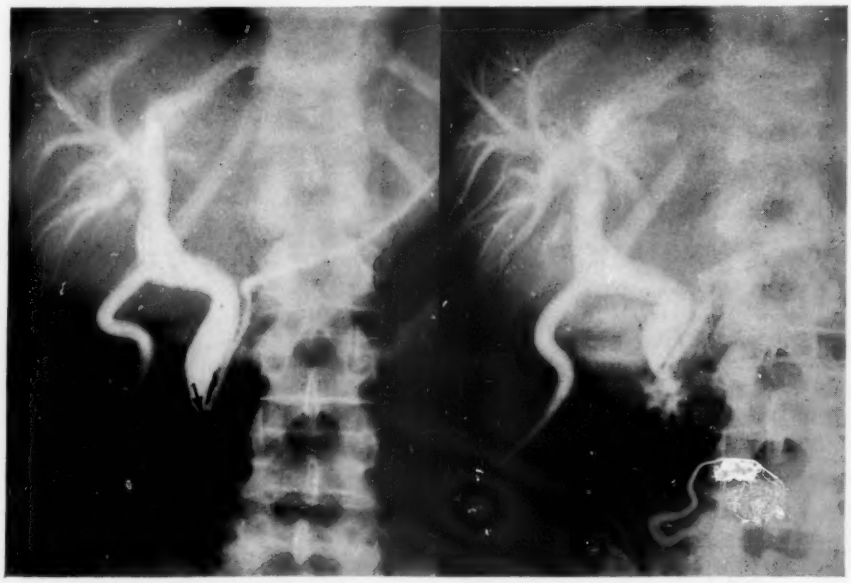
manometer read zero, and at that point the reservoir was clamped off from the rest of the system. Usually a slow rise of the manometer occurred to indicate the pressure within the ductal system. It is this pressure in which we have been most interested.

All our readings were taken with the patients supine, and the subjects were all sufficiently cooperative to lie quietly during the course of the studies.



A B

FIG. 2.—(A) In this instance, the biliary fistula would not close and a cholangiogram revealed a filling defect at the lower end of the common duct. (B) After the described treatment, no foreign body was visible on the check-up cholangiogram and the fistula closed in three days.



A B

FIG. 3.—(A) Postoperative cholangiogram revealed a stone remaining in the lower end of the common duct. (B) After several courses of treatment, cholangiogram shows that the stone has been dislodged from the common duct.

Nothing was given by mouth during the time the apparatus was in use except as is indicated in our results. The curves represent the typical readings of a particular patient as recorded over a number of hours on a given day. The water in the manometers would immediately seek a level, which indicated the pressure within the ductal system and which was followed for varying periods of time.

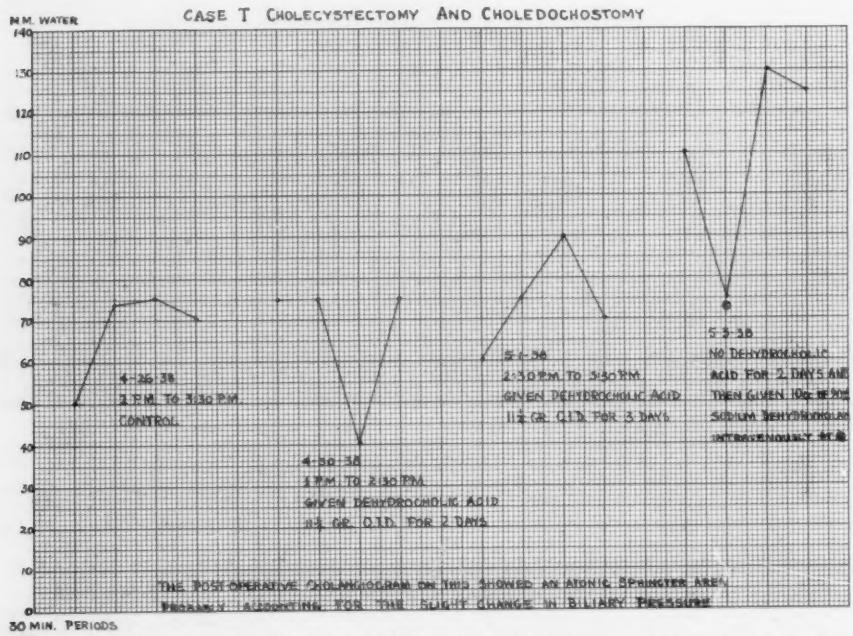
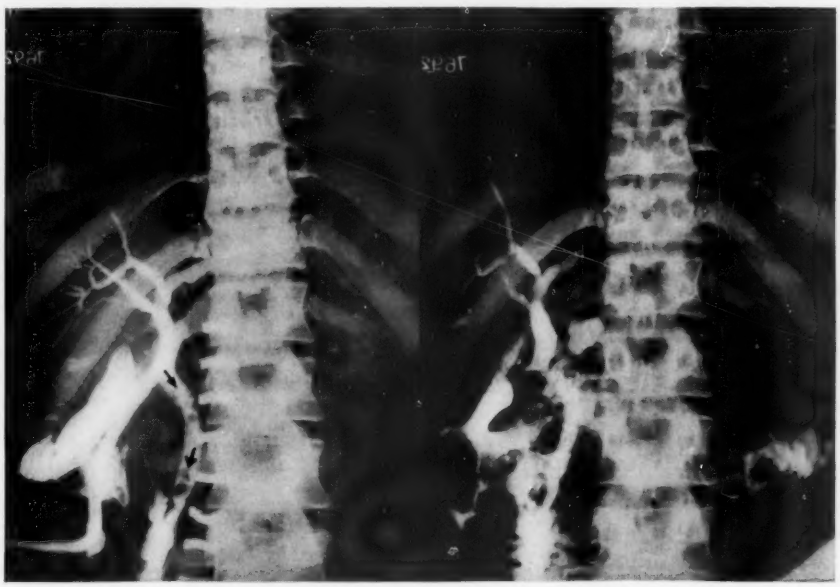



CHART 6.—Case 6: Mrs. T., age 40. Although the patient was given dehydrocholic acid, no increase in intraductal pressure occurred. A cholangiogram revealed an atonic sphincter of Oddi, which permitted very free egress of all the contrast medium into the duodenum. After intravenous administration of sodium dehydrocholate, the intraductal pressure increased somewhat.

*Interpretation.*—The accompanying charts reveal the pressure within the common duct following cholecystectomy and choledochostomy. Of course, the pressure might be altered slightly by the presence of the T-tube within the duct, but some unnatural condition is necessary for the recording of the pressure, and all changes may be considered relative. The common duct pressure in the cases reported, as well as in some others not reported in this series, has been found to vary between 50 and 125 Mm. of water. This rather wide variance would seem natural in view of the mechanics and physiology of digestion in different individuals and also at different times in the same individual. The liver secretory pressure, the amount of bile arising at the source in the liver, the inhibitory forces that might be present at the outlet of the bile tubal system, are all factors which will alter the pressure within the duct. Obstructing agents within the duct may cause the pressure to vary as exemplified by Case 3. A choleretic drug, such as decholin or procholon, the commercial products of dehydrocholic acid, may alter conditions at the bile source through stimulation of the secretory cells of the liver, as proved by various investigators previously

mentioned. The graphs of the five cases presented in this study show that the stimulation is usually accompanied by a definite increase of intraductal pressure, varying between 25 and 75 Mm. of water, when the drug is given orally.

We have observed in giving the drug over a period of three to five days, that the intraductal pressure not infrequently returns to a level rather close to the control period. This is illustrated in Case 4, and it may be due to lowering of the "break" pressure at the lower end of the common duct by the unusual intraductal pressure or by direct effect of the drug upon the choledochal



A B

FIG. 4.—(A) The postoperative cholangiogram reveals multiple stones in the common duct, although none had been found at operation. These probably came from the higher levels of the hepatic ducts. (B) After two courses of the described treatment, the cholangiogram reveals no remaining stones. Eleven stones were removed from the stools during the period of treatment.

sphincter area. Reference to the investigations of others does not reveal a corresponding drop in the amount of bile fluid at this period. In cases where the dehydrocholic acid is withdrawn for some days and then is administered again, the expected increase in pressure usually occurs, but it usually does not reach the height attained after the first administration of the drug. When the dehydrocholic acid is discontinued, the ductal pressure usually returns to the control level (Cases 1 and 5).

Intravenous administration of the sodium salt of dehydrocholic acid (decholin sodium) results in an immediate increase of the intraductal pressure, usually sustained for only 10 to 30 minutes, after which it drops back to the control level (Cases 1 and 2). However, in most instances it rises 25 to 50 Mm. of water higher than when the drug is given by mouth, as exemplified in Case 1. One can well say the rise is sudden and dramatic.

In Case 3, raising of the pressure was brought about by a partial obstruction, probably a mucous plug, at the lower end of the common duct. This was revealed by the cholangiogram and the effect of nitroglycerin in relaxing the sphincter area and partially relieving the obstruction was also well demonstrated.

Our findings do not permit us to agree with Elman and McMaster,[6, 7] who state that, in general, feeding lowers the resistance to bile flow, which may be interpreted as resulting in a lowered intraductal pressure, as in Case 5 of our series the taking of food resulted in an immediate rise of the intraductal pressure. We also believe that the type of food is most important. A rough diet would probably cause irritation of the sphincter area, while a soft, smooth diet would necessarily be less disturbing. Likewise, a fat reaching this area would probably tend to decrease the pressure by relaxing the sphincter musculature. The time element leads one to believe that the pressure increase following food intake results from closure or tightening of the sphincter area at the lower end of the common duct. However, these authors mention a secondary increase in resistance to bile flow occurring some 20 to 25 minutes after a meal, and since our readings showed that the maximum pressure was attained about 15 minutes after the meal, our findings may be considered similar. This rise in pressure, due apparently to changes in the sphincter area, may be the disturbing phenomenon that gives rise to distress in biliary tract disease, or in the patient from whom the gallbladder has been removed, it may be the cause of the postcholecystectomy syndrome.

*Clinical Application.*—As stated in the introductory paragraph of this paper, our experiences with cholangiography have definitely proved to us that stones are not infrequently left within the common duct or are washed down from the liver into the common duct later; that plugs of mucous or inspissated bile not infrequently inhibit the free flow of bile in the common duct and that even blood clots may be the source of obstruction (Figs. 2, 3 and 4). If these remain within the common duct, biliary symptoms persist or are aggravated and thus account for many of the poor results following cholecystectomies.

In the past, operative intervention was necessary or the patient's distress continued, unless nature expelled the foreign body from the duct. If the patient has a persistent biliary fistula or if a T-tube or catheter has been placed within the common duct, a definite picture of the obstruction may be obtained by injecting 10 to 25 cc. of a sterile contrast medium, such as a 48 per cent solution of hippuran, into the tract or tube. In most cases, we have been able to dislodge these foreign bodies by the following method, unless the obstructing agent was an exceedingly large stone. The pressure within the duct is increased by giving three or four tablets of decholin (3¾ Gr.) or procholon four times a day for three days. On the first day, 1/100 Gr. nitroglycerin is dissolved under the tongue three times during the day, to relax the lower end of the common duct and permit the increased bile flow and pressure to flush out the duct. On the second day, atropine Gr. 1/100 to 1/150, is given by mouth or

hypodermically three times. On the third day, the nitroglycerin is repeated. Each morning before breakfast, during this three-day regimen, the patient is given one to two drams of magnesium sulphate in water and preceding the evening meal and at bedtime, one ounce of pure cream or olive oil, which also aids in relaxing the sphincter area at the lower end of the common duct.

During any momentary relaxation of the sphincter area afforded by these drugs, the increased intraductal pressure may force or flush the foreign body out of the common duct. If a T-tube is present or a biliary fistula exists, the common duct is irrigated each day with sterile, warm normal saline solution followed by sterile, warm olive oil or warm iodized oil such as lipiodol or lipiodine. We now keep the tube clamped or the fistulous tract packed for two to three hours following each administration of the nitroglycerin or atropine. During the night, one may or may not keep the T-tube clamped, depending somewhat upon the degree of obstruction and the amount of pain ensuing. This regimen is now used in all gallbladder cases postoperatively, and since common duct pathology is so common and possibly is the cause of distress in many cases of nonoperative biliary tract disease, it is also used in the medical management of this condition. We have also proved that intrahepatic duct stones may be washed down from the liver by this method. Jaundice with complete obstruction of the common duct definitely contraindicates this method of treatment.

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# HABITUAL DISLOCATION OF THE DIGITAL EXTENSOR TENDONS

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WHEN the fingers are flexed the extensor tendons can be seen to stand out on the rounded heads of the metacarpal bones. Each tendon rests accurately on the apex of the smooth cartilage-covered surface of the bone-end, without any tendency to slide off. The tighter the fist is clenched, the more securely the tendon holds its position. The principal mechanism holding each tendon in place is its adhesion to the capsule of the metacarpophalangeal joint. The intertendinous tissues on the dorsum of the hand also help to hold the tendons in their position, principally through the juncturae tendinum, which are constantly present over the two lateral interosseous spaces, uniting the tendons of the middle, ring, and little fingers. The extensor expansions on the dorsum of each proximal phalanx also assist in keeping each tendon in its proper alignment.

The efficiency of this retaining mechanism is attested by the rarity of reports of habitual displacement. One would expect that pugilists would be likely to suffer from dislocation of tendons on the knuckles, but if such is the case no reports have been placed on record. Krukenberg[1] first wrote of the condition, in 1890. Haberern,[2] in 1902, gave a description of a case, with an operation for its cure, by constructing a restraining sheath from the subcutaneous tissues and strips of the capsule of the metacarpophalangeal joint. Reports by Paget, Legouest and Howard Marsh were mentioned in this paper. In 1921, Levy[4] collected six cases from the writings of others, and added four of his own. He recognized pathologic, traumatic, and hereditary types, and approved of the Haberern operation.

**Case Report.**—On September 10, 1936, a young woman, age 22, stenographer, complained that she was unable to use her left hand in operating a typewriter on account of pain in the forearm, associated with slipping of the extensor tendons from the heads of the metacarpal bones whenever the fingertips were pressed on the keys.

Two years previously she had first noticed that the tendon of the index finger slipped off the head of the bone toward the ulnar side whenever the fist was clenched. This sliding of the tendon was always accompanied by an unpleasant sensation passing upward into the forearm. Three weeks before coming for advice, the tendon of the middle finger began to slip in an ulnar direction, and the pain became worse. A fortnight later the tendons of the ring and little fingers became similarly displaced. There was a boring pain, deep in the extensor muscles of the forearm, the hand felt cold, and perspired freely. She obtained relief by allowing the hand to hang loosely by the side. No relative of the patient had ever suffered from a similar condition.

*Physical Examination.*—There was slight wasting (½ cm. in circumference) in the arm and forearm. There was no displacement of the tendons when the interphalangeal joints were flexed with the metacarpophalangeal joints extended; neither was there any slipping when the metacarpophalangeal joints were flexed while the interphalangeal

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were kept straight. But when all three joints were flexed the tendons slid off the heads of the bones with a visible jerk, associated with an irritating sensation of deep soreness in the forearm.

The tendons of the index, middle, and little fingers always went to the ulnar side; that of the ring finger to the radial side of the corresponding bone (Fig. 1). The tendons slid abruptly back into position as soon as extension was begun.

FIG. 1.—Before operation: The tendons of the index, middle, and little fingers are displaced toward the ulnar side of the head of the corresponding metacarpal. That of the ring finger has slid off in a radial direction. Pain was felt in the forearm.

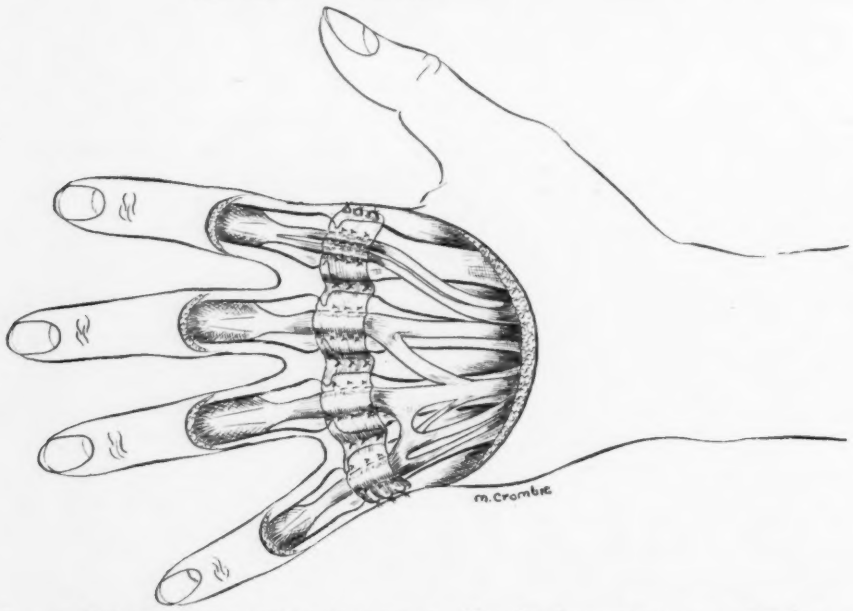


FIG. 2.—Method of fixing the fascial strip in position. Note that the common extensor expansions are absent over the upper part of the proximal phalanx.

*Operation.*—September 29, 1936: Under general anesthesia, a strip of fascia lata 12 cm. long and ½ cm. wide was removed from the outer side of the right thigh. Three longitudinal incisions were then made over the interosseous spaces and continued distally along the dorsum of the index, ring, and little fingers. The extensor

tendons had a normal attachment to the fibrous capsule of the joint. Juncturae tendinum were seen to be present. The common extensor aponeurosis, however, did not appear to extend as far proximally as usual. In a normal hand the proximal edge of the extensor expansion is situated at the metacarpophalangeal joint line, and in fact, in hyperextension it slips over a part of the metacarpal head and partly covers its articular

FIG. 3.—Two months after operation: The scars are visible, and the tendons remain in place on flexion. No pain. (The ridge on the radial side of the head of the index metacarpal is due to a distended vein.)

surface. In some dissections it blends with the capsule of the metacarpophalangeal joint. Apparently, in the instance here described, it was the absence of this usually well developed proximal part of the common extensor aponeurosis that permitted the tendons to slide off the smooth heads of the bones during flexion of the digits.

The strip of fascia lata was anchored to the periosteum on the radial side of the head of the index metacarpal with silk sutures. It was also anchored to the transverse ligament of the heads of the bones between each pair of metacarpals, and to the periosteum on the ulnar side of the fifth metacarpal. Fine sutures were then placed along both sides of each tendon, anchoring the strip of fascia lata down to the joint capsule. At the close of the operation each tendon was held down to the fibrous joint capsule in a tunnel of fascia lata, which in turn was fastened to each side of the deeper tissues (Fig. 2). The skin was closed with fine silk sutures. The wounds healed by primary union, and exercises were begun in ten days (Fig. 3).

*Follow-Up.*—On November 20, 1936, the patient returned to her work as a stenographer, and ever since that date she has been able to type at the same speed as before. The pain has completely disappeared. The tendons remain in place on all movements. The range of movement of the metacarpophalangeal joints is two-thirds that of normal; that of the interphalangeal joints is normal.

SUMMARY

In a patient with habitual dislocation of the digital extensor tendons, dissection at operation showed that the proximal edge of each common extensor expansion was placed a little further distally on the proximal phalanx than is usually the case. This anatomic fact is offered as an explanation of the dislocation. An operation for the cure of the condition is described.

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# STUDIES OF CYCLOPROPANE
# THE USE OF BARBITURATES IN PREVENTING CARDIAC IRREGULARITIES UNDER CYCLOPROPANE OR MORPHINE AND CYCLOPROPANE ANESTHESIA

## AN EXPERIMENTAL STUDY

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PATIENTS anesthetized with cyclopropane, after the usual premedication with morphine and atropine, frequently develop cardiac irregularities during some stage of the anesthesia. In the course of an experimental investigation, it was found that in dogs anesthetized with cyclopropane alone, cardiac irregularities were very rarely encountered until after respiratory arrest, whereas, in those medicated with morphine and anesthetized with cyclopropane, cardiac irregularities were present in practically all cases during some stage of anesthesia. Dogs that are given barbiturates as preanesthetic medication do not develop cardiac irregularities with cyclopropane during surgical anesthesia and only rarely after respiratory arrest.

Lucas and Henderson[1] were the first to observe occasional irregularities of the heart in animals under cyclopropane anesthesia. Kurtz, Bennett, and Shapiro,[2] in an electrocardiographic study, found ventricular extrasystoles in over one-half and multiple focus ventricular tachycardia in 10 per cent of their patients anesthetized with cyclopropane.

Seevers, *et al.*,[3] in a study on dogs under cyclopropane anesthesia, found that cardiac irregularities came on at the time of, or soon after, respiratory arrest, and that normal rhythm would return immediately upon giving artificial respiration or reducing the concentration of cyclopropane in the bag by diluting with oxygen. They also found that atropine would abolish the initial irregularities and state that these are probably of vagal origin. Robbins and Baxter[4] reported a study similar to that of Seevers, *et al.*, except that they made analyses of the blood for oxygen, carbon dioxide, and cyclopropane, and found that the electrocardiographic changes were always associated—except in one of 13 dogs—with severe anoxemia, and that with adequate artificial respiration the heart remained normal with a much higher concentration of cyclopropane in the blood than that necessary to produce respiratory arrest. In a study analyzing the effect of cyclopropane upon the different properties of the heart, Meek, Hathaway, and Orth[5] have shown that the heart of a dog anesthetized with cyclopropane is more sensitive to an injection of a small amount of epinephrine than the heart of a normal dog or of one under chloro-

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form or ether, and state that cyclopropane increases the irritability of the automatic tissues of the heart more than these other agents.

Many investigators[6] have reported that certain barbiturates reduced or abolished the effect of vagal stimulation upon the heart; in a recent paper by Gruber, *et al.*,[6] a review of this subject is presented. Seevers and Meek,[7] and Hoff and Nahum[8] showed that some of the barbiturates prevented the development of cardiac irregularities following the intravenous injection of ephedrine or calcium chloride, which increase the irritability of the heart.

The effect of morphine upon the rate and rhythm of the heart has been studied by many investigators, and all are agreed that the bradycardia and arrhythmia result from excessive vagal tone. Jackson and Ewing[9] found that morphine reduces the threshold for the vagal reflexes; McCrea and Meek[10] believe that the primary site of action of morphine in producing the changes in heart rate and rhythm is in the cerebrum, but more recent studies by Robbins, Fitzhugh and Baxter[11] show that the typical morphine bradycardia persists after decerebration of the dog.

Cyclopropane anesthesia intensifies the bradycardia and arrhythmia in dogs medicated with morphine; an analysis of this action, which will be published elsewhere,[12] showed that cyclopropane increased the action of morphine through the vagal system.

With evidence that barbiturates depress vagal tone and decrease the irritability of the automatic tissues of the heart and that the irregularities under morphine and cyclopropane anesthesia are due in part to vagal action and increased irritability of the automatic tissues, we decided to follow up our earlier observations of barbiturate-cyclopropane and morphine-cyclopropane action on the heart.

METHODS.—*Electrocardiogprahic Study:* A standard Cambridge electrocardiograph was used. The records were taken from Lead II and were analyzed for rate, P-R interval, and T-wave changes, as well as for abnormalities.

*Blood Gases:* The Van Slyke-Neill manometric apparatus was used for the oxygen and carbon dioxide analyses. Arterial blood was collected under oil and one cubic centimeter samples were analyzed; duplicate analyses were not made routinely. The cyclopropane content of the blood was determined on five cubic centimeter samples by the iodine pentoxide oxidation method as described in an earlier paper.[13]

*Preparation of the Anesthetics and Mode of Administration*: Morphine sulphate was given subcutaneously; barbital or amytal was used in a 10 per cent solution and was injected into the great saphenous vein in the amounts recorded in the tables. Thirty minutes after the injection of the preanesthetic drug, anesthesia was completed by having the dog rebreathe in a bag containing a mixture of cyclopropane and oxygen. As soon as anesthesia was sufficiently deep to permit, a tracheal catheter with an inflatable cuff was inserted and then connected in line with the soda-lime filter and bag containing the anesthetic mixture. The bag was emptied and refilled two or three times dur-

ing each experiment in order to remove the inert gas. Oxygen was added continuously at the rate of its consumption.

*Animal Experiments:* The dog was placed, back down, on a dog board, and connections were made for taking electrocardiographic records. After the control record was made, the right hind leg was shaved for the intravenous injection of the barbiturate. The barbiturate was injected over a period of one or two minutes. Thirty minutes after the injection of the barbiturate or morphine, a second electrocardiographic record was made, and then the anesthesia was completed by giving cyclopropane in oxygen. The dog was kept in deep surgical anesthesia for 30 minutes, and then arterial blood samples were drawn for oxygen, carbon dioxide, and cyclopropane analyses; an electrocardiographic record was made. The image of the string was under constant observation from the time of administration of cyclopropane.

TABLE I

| Exper. No. | —Premedication— Type | Amount | Arterial Gases — Surgical Anesthesia $O_2$ | Surgical Anesthesia $CO_2$ | Respiratory Arrest $O_2$ | Respiratory Arrest $CO_2$ | Respiratory Arrest $C_3H_6$ | Cardiac Arrest $O_2$ | Cardiac Arrest $CO_2$ | Interval Between Respiratory Arrest and Cardiac Arrest | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mg./Kg. | Per Cent | Per Cent | Per Cent | Per Cent | Mg. | Per Cent | Per Cent | Minutes | |
| 1 | Barbital | 250* | 14.5 | 57.0 | 18.8 | 60.0 | 23.1 | 3.9 | 78.0 | 31 | No irregularities |
| 2 | Barbital | 250 | | | 21.0 | 51.0 | 20.9 | 4.3 | 79.0 | 42 | No irregularities |
| 3 | Barbital | 250 | | | 17.6 | 55.5 | 25.8 | 2.4 | 60.0 | 10 | No irregularities |
| 4 | Barbital | 250 | 16.8 | 45.5 | 18.6 | 59.0 | 23.2 | 1.9 | 63.0 | 8 | Two ventricular extrasystoles before arrest |
| 5 | Barbital | 250 | 21.8 | 53.5 | 22.9 | 67.5 | 26.0 | 5.3 | 77.0 | 20 | Slowing to arrest |
| 6 | Barbital | 250 | | | 25.0 | 61.0 | 27.6 | 4.1 | 64.0 | 8 | Slowing to arrest |
| AV. | Barbital | 250 | 17.7 | 52.0 | 20.65 | 59.2 | 24.6 | 3.6 | 70.1 | 20 | |
| 14 | Barbital | 150 | 19.1 | 44.8 | 23.5 | 58.0 | 26.8 | 2.3 | 74.8 | 18 | Slowing to arrest |
| 15 | Barbital | 100 | 18.1 | 49.5 | 17.9 | 63.2 | 31.0 | 2.2 | 70.5 | 7 | AV block; nodal |
| 7 | Amytal | 30 | 18.5 | 48.5 | 18.0 | 62.0 | 26.1 | 4.4 | 69.7 | 14 | No irregularities |
| 9 | Amytal | 30 | 17.0 | 43.5 | 21.0 | 55.4 | 26.8 | 2.8 | 66.7 | 30 | Slowing to arrest |
| 10 | Amytal | 30 | 19.3 | 47.8 | 23.4 | 61.0 | 34.7 | 3.1 | 72.0 | 18 | Slowing to arrest |
| 11 | Amytal | 30 | 16.4 | 47.4 | 20.2 | 59.6 | 34.6 | 2.6 | 70.6 | 23 | Slowing to arrest |
| 12 | Amytal | 30 | 17.5 | 44.3 | 19.2 | 55.5 | 26.8 | 3.6 | 65.7 | 12 | Slowing to arrest |
| 13 | Amytal | 30 | 18.0 | 45.2 | 20.8 | 55.4 | 34.6 | 3.5 | 69.5 | 17 | Slowing to arrest |
| AV. | Amytal | 30 | 17.8 | 46.1 | 20.4 | 59.1 | 30.6 | 3.3 | 69.0 | 19 | |
| 19 AV. | Control | — | 18.95 | 42.7 | 15.4 | 51.2 | 32.7 | 2.25 | 55.6 | 6.2 | Nodal rhythm, 16 dogs; AV block, 6 dogs; V. ex., 5 dogs |

* The large doses of barbital and amytal reported in this table were used to see if one could prevent the development of cardiac irregularities which are observed in dogs after respiratory arrest, produced by cyclopropane, when the arterial oxygen content has been reduced to 3 to 4 volumes per cent. Severe anoxemia alone will cause irregularities of the type shown in Figure 3.

The concentration of cyclopropane in the inspired cyclopropane-oxygen mixture was gradually increased until respiration stopped. Blood samples were then collected for analysis, and an electrocardiographic record was made. During the interval between respiratory arrest and cardiac arrest, which varied from seven to 42 minutes in the dogs given barbiturates, frequent electrocardiographic records were made, and blood samples were collected every five minutes for gas analysis. Immediately after cardiac arrest, final blood samples

were collected. By following the change in pulse rate and pressure manually, as well as by watching the image of the electrocardiographic string, we were able, in a majority of the experiments, to predict the time of cardiac arrest, so that the final record showed the complexes just prior to arrest.

In this study, eight dogs were given barbital in doses of 100 to 250 mg. per kg., and six were given amytal in 30 mg. per kg. doses. Six dogs were given morphine sulfate in 5 mg. per kg. doses.

TABLE II

EXPERIMENT NO. 19. DOG, 9.7 KG.; MALE

| Time | Stage | Arterial $CO_2$ Per Cent | Arterial $O_2$ Per Cent | Arterial $C_3H_6$ Mg. | E.K.G. Number | Heart Rate | P–R Interval | T-Wave | Rhythm |
|---|---|---|---|---|---|---|---|---|---|
| 1:10 | Control | 41.0 | 15.7 | — | 1 | 140 | .1 | + | Slight sinus arrhythmia |
| 1:15 | Morphine | — | — | — | — | — | — | | |
| 1:45 | — | 42.6 | 16.0 | — | 2 | 70 | .1 | + | Marked sinus arrhythmia |
| 1:50 | $C_3H_6$ on | — | — | — | — | — | — | | |
| 1:52 | — | — | — | — | 4 | 52 | .12 | + | Sinus arrhythmia; nodal extrasystoles |
| 1:58 | $III_3$ | — | — | — | 5 | 48 | .11 | | Nodal and ventricular extrasystoles |
| 2:05 | $III_3$ | 45.2 | 17.5 | 17.6 | 6 | 48 | .11 | + | Ventricular extrasystoles |
| 2:15 | $III_{3-4}$ | — | — | — | 7 | 50 | .10–.12 | + | Ventricular extrasystoles |
| 2:25 | $III_4$ | 46.8 | 16.1 | 23.4 | 8 | 46 | .12 | + | Ventricular extrasystoles |
| 2:50 | IV | 57.2 | 16.2 | 27.0 | 12 | 62 | .12 | + | Slight sinus arrhythmia |
| 2:51 | $C_3H_6$ off Recovery | — | — | — | — | — | — | | |

TABLE III

EXPERIMENT NO. 13. DOG, 11.6 KG.; FEMALE

| Time | Stage | Arterial $CO_2$ Per Cent | Arterial $O_2$ Per Cent | Arterial $C_3H_6$ Mg. | E.K.G. Number | Heart Rate | P–R Interval Seconds | T-Wave | Rhythm |
|---|---|---|---|---|---|---|---|---|---|
| 8:55 | | | | | 1 | 150 | .10 | — | Sinus arrhythmia |
| 9:00 | Amytal 30 mg./Kg. | | | | | | | | |
| 9:20 | I | | | | 2 | 140 | .08 | — | Regular |
| 9:25 | $C_3H_6$ on | | | | | | | | |
| 10:00 | $III_3$ | 45.2 | 18.0 | 10.4 | 3 | 175 | .07 | — | Regular |
| 11:00 | IV | 55.4 | 20.8 | 31.0 | 5 | 220 | .07 | — | Regular |
| 11:05 | IV | 63.5 | 18.95 | | 6 | 250 | .07 | — | Regular |
| 11:10 | IV | 65.5 | 15.7 | | 8 | 210 | .08 | — | Regular |
| 11:15 | IV | 67.8 | 8.4 | | 10 | 175 | .08 | — | Regular |
| 11:175 | | 69.5 | 3.58 | 34.6 | 12 | 40–0 | .10 | — | Slowing to arrest |

The results of this investigation are shown in Table I, in which are recorded the type and amount of premedication, the arterial oxygen and carbon dioxide content in surgical anesthesia, at respiratory arrest, and at the time of cardiac arrest, the concentration of cyclopropane in the blood at the time of respiratory arrest, and finally remarks as to the type of cardiac arrest. The data in the bottom line are taken in part from an earlier paper[4] with the addition of results from six other experiments.

Protocols of two experiments are given in Tables II and III; electrocardiographic records from these two experiments are shown in Figures 1 and 2.

The first abnormal electrocardiographic record from each of five non-premedicated dogs is shown in Figure 3. These irregularities developed on an average of 4.3 minutes after respiratory arrest produced by cyclopropane alone; the arterial oxygen content was 3.9 volumes per cent at the time these records were made.

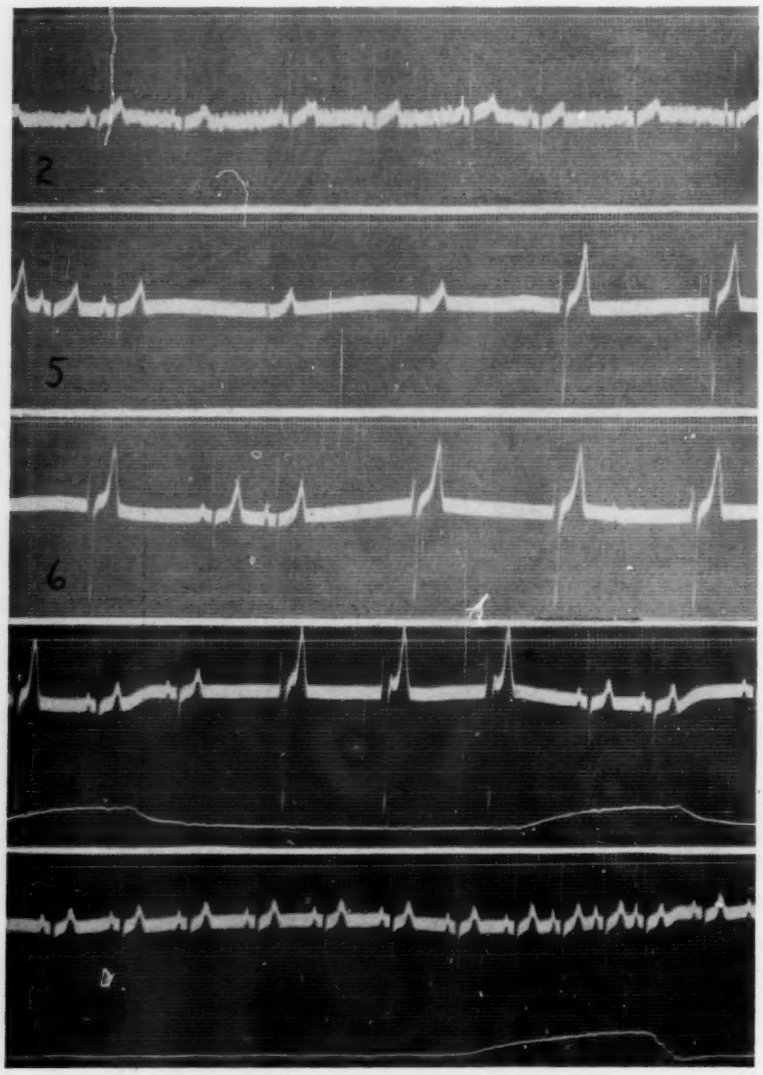


FIG. 1.—Electrocardiographic Records from Experiment 19: Morphine, 5 mg. per Kg., was given as a preanesthetic drug.

Consult Table II for data which correlate the stage of anesthesia, arterial concentration of oxygen, carbon dioxide, and cyclopropane with the first three records in this figure.

The irregularities of the heart in dogs under morphine-cyclopropane anesthesia are due to excessive vagal tone. In records 16 and 18 the respiratory activity is correlated with the heart record. The physiologic depression of the vagus center during inspiration permits the heart to beat normally, as shown in record 16. Two minutes after record 16 was made, the dog was given 10 mg. per Kg. of amytal intravenously; three minutes later record 18 was made. This shows that amytal abolishes the excessive vagal tone.

*Discussion.*—In the dogs receiving morphine, the heart rate fell from a control of 134 to 73; only one dog showed abnormal rhythm before cyclopropane. Anesthesia produced with cyclopropane reduced the rate to 54 per

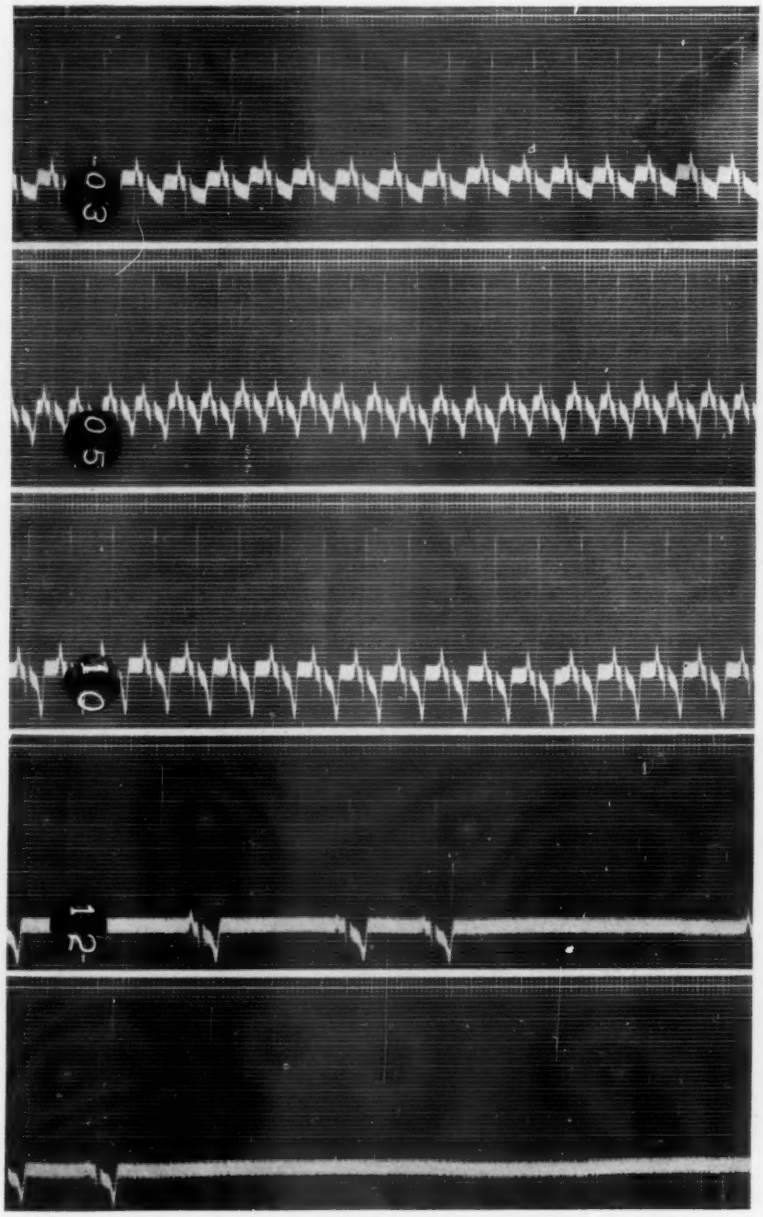


FIG. 2.—Electrocardiographic Records from Experiment 13; Amytal, 30 mg. per Kg. was given as a preanesthetic drug.

Consult Table III for data which correlate the stage of anesthesia, arterial concentration of oxygen, carbon dioxide, and cyclopropane with the records in this figure.

The heart stopped 17.5 minutes after respiratory arrest, as shown in record 12; the arterial oxygen content was 3.58 volumes per cent.

minute, and all dogs showed either nodal or ventricular extrasystoles, even though the arterial oxygen was 17.4 volumes per cent. These results are markedly different from those obtained from dogs receiving cyclopropane alone and from dogs receiving barbiturates before the cyclopropane.

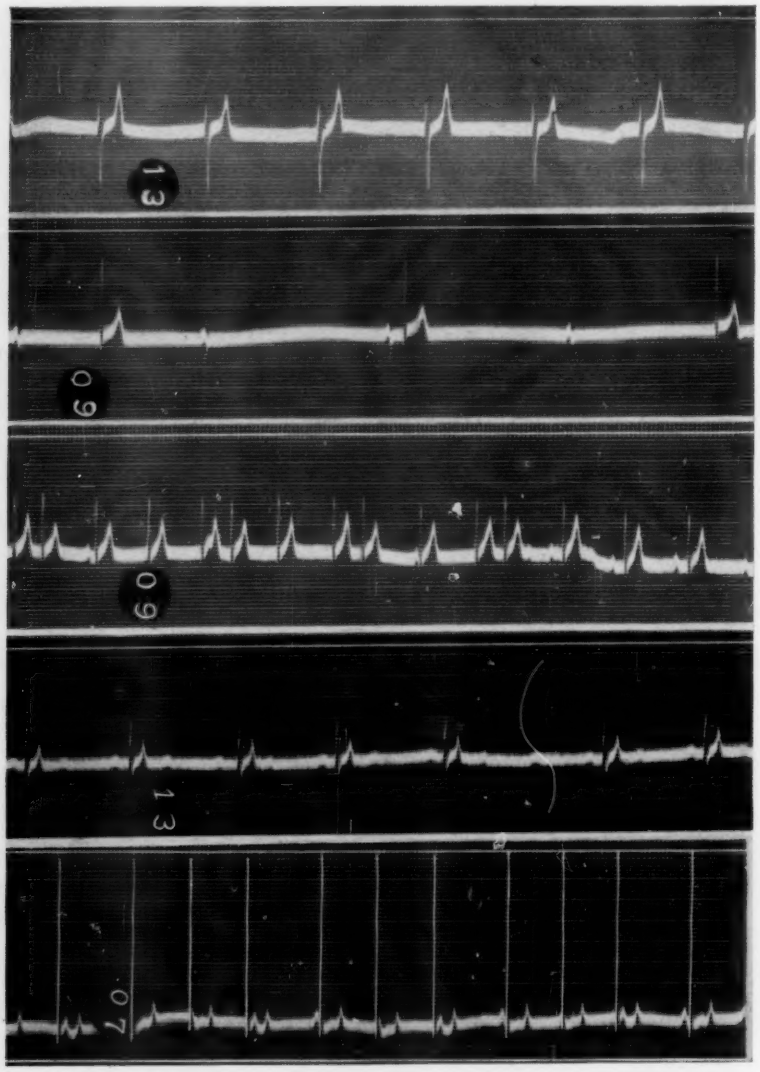


FIG. 3.—Electrocardiographic Records from Five Dogs Which Received No Preanesthetic Medication: The dogs were forced to respiratory arrest by gradually increasing the cyclopropane content of the anesthetic mixture. There were no cardiac irregularities present before respiratory arrest. The irregularities shown above developed 4.3 minutes after respiratory arrest and with an arterial oxygen concentration of 3.9 volumes per cent.

13—Ventricular extrasystole arising from a single focus.

09—Complete auriculoventricular dissociation with slow rate; auricles 32/1′, ventricles 20/1′.

09—Tachycardia of nodal origin, 140/1′.

13—Partial AV. block 2:1 to 3:1.

07—Auriculoventricular dissociation—auricles regular, 100/1′; ventricles irregular, 100/1′. The shadow of the upstroke of R has been intensified.

The records from the dogs receiving barbiturates show some things in common with the records of the nonpremedicated control dogs. The arterial oxygen concentrations at which arrhythmias or arrest occurred are approximately the same in each group. The concentration of cyclopropane in the blood of the dogs receiving the smaller doses of barbital and in all those receiving amytal is of the same order of magnitude as the concentration in the control dogs, so that the difference in the cardiac picture cannot be ascribed to a difference in the cyclopropane content.

There are three significant differences between the control group and the barbiturate-premedicated groups. First, cardiac irregularities or arrest developed in the control dogs on an average of six minutes after respiratory arrest, whereas, in the barbital- and amytal-treated groups the cardiac arrest occurred about 20 minutes after respiratory arrest. Second, cardiac irregularities were recorded in 17 of the 19 control dogs (16, nodal rhythm; five, auriculo-ventricular block; six, ventricular extrasystole), whereas, in the 14 dogs receiving barbiturates, irregularities were observed and recorded in only two dogs. This is particularly significant when one considers that in the group of dogs receiving amytal, in which the cyclopropane concentration was equal to that in the controls, the final electrocardiographic records show normal complexes even up to cardiac arrest. Third, the arterial content of oxygen is increased at the time of respiratory arrest in the premedicated dogs. In the control group, the oxygen content in surgical anesthesia was 18.95 volumes per cent and at respiratory arrest was 15.40 volumes per cent, whereas, in the amytal group the values were 17.8 and 20.4 volumes per cent, respectively, and in the barbital group the concentration at respiratory arrest was 20.5 volumes per cent. In three dogs receiving barbiturate-premedication the oxygen capacity of the arterial blood in surgical anesthesia and at respiratory arrest was found to be 17.8 volumes per cent and 19.9 volumes per cent, respectively.

Dogs anesthetized with cyclopropane to the stage of respiratory arrest are easily revived by discontinuing the anesthetic and giving artificial respiration for a few seconds. In a group of dogs which received barbiturate-premedication and were forced to respiratory arrest with cyclopropane, several were revived five to 35 minutes after respiratory arrest.

We believe that these results may warrant the trial of a barbiturate in place of morphine as a preanesthetic drug with cyclopropane; until further studies on other barbiturates are completed, amytal is suggested for this use. This suggestion is based on several considerations. The general reports from anesthetists are that the cardiac irregularities observed with cyclopropane are of two types: First, a bradycardia with ventricular extrasystoles—due probably to excessive vagal tone. Second, a tachycardia of nodal or ventricular origin that may be explained on an increased irritability of the automatic tissues of the heart, as reported by Meek, Hathaway, and Orth.[5] In the experiments reported, we have shown that morphine and cyclopropane combined produced a marked bradycardia and irregularities in dogs in surgical anes-

thesia even in the presence of adequate arterial oxygen, and that amytal, in one-half the anesthetic dose, prevented the development of cardiac irregularities in the presence of high cyclopropane concentration in the arterial blood and severe anoxemia. We feel that amytal reduces the excessive vagal tone which is present with morphine and cyclopropane anesthesia and also that the increased irritability of the myocardium and automatic tissues, due to cyclopropane and anoxemia, is reduced to a level below the irritability of the sinu-auricular node.

There is little reason to believe that the combination of amytal and cyclopropane will depress the respiration to such an extent that anoxemia will result before respiratory arrest, because blood gas analysis shows adequate oxygen not only at the time of but even for several minutes after respiratory arrest.

The amount of amytal found to be effective in abolishing the cardiac irregularities routinely observed during surgical anesthesia in dogs premedicated with morphine and anesthetized with cyclopropane, could be used clinically. A dose of amytal, 10 mg. per Kg., which will abolish the morphine-cyclopropane irregularities in dog is equal to 20 per cent of the anesthetic dose; by analogy an equivalent amount for man would be 4 to 5 mg. per Kg., or 280 to 350 mg. for the average adult. This amount of amytal would not be considered excessive premedication in the absence of morphine.

It remains for the clinical anesthetist to determine if such premedication will reduce the frequency of cardiac irregularities in man during anesthesia with cyclopropane.

## SUMMARY

(1) In a series of 20 dogs receiving morphine, barbital, or amytal as premedication agents for cyclopropane anesthesia, the blood gas concentrations have been correlated with changes in the heart as shown by electrocardiographic records.

(2) In dogs premedicated with morphine, bradycardia and arrhythmia are usually present in the different levels of surgical anesthesia produced with cyclopropane. Intravenous injection of amytal abolishes the bradycardia and arrhythmia.

(3) Cardiac irregularities which develop at the time of or soon after respiratory arrest produced by cyclopropane alone may be prevented by barbital or amytal.

(4) These experiments indicate that a barbiturate should be given a clinical trial in place of morphine as preanesthetic medication in patients to be anesthetized with cyclopropane.

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# THE APPLICATION OF CARBAMIDE (UREA) THERAPY IN WOUND HEALING*

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RECENTLY, Reid[1] pointed out that "it is erroneous to give . . . the idea that the problem of wound healing is essentially synonymous with the principles of asepsis and antisepsis." He notes further, that "among the first of the great principles of wound healing to become established, was the importance of eliminating or preventing the formation of necrosis and débris in wounds." By the removal of dead tissues, bacterial growth is eliminated or reduced to a minimum. Christopher[2] likewise condemns the use of antiseptics in fresh open wounds, and lists the removal of foreign bodies and devitalized tissues as two of the most important underlying principles in the treatment of fresh wounds. It was the consideration of the importance of this factor which first led us to examine the usefulness of a strong carbamide* (urea) solution, which is a potent agent for dissolving protein substances, such as dead tissues, as a therapeutic agent in wound healing.[4] This rediscovery of an agent, first used more than three decades ago,[5] but since forgotten, has produced such good results that an unexpected interest as well as innumerable questions concerning the details of its application to wounds of various types have arisen. It has, therefore, seemed desirable to describe the application of carbamide (urea) in greater detail and to summarize two more years' experience with the product.

The virtues of carbamide have recently been well summarized by Mertins,[6] essentially as follows:

(1) Carbamide in aqueous saturated solution, by its power of dissolving necrotic débris, removes the chief deterrent to healing in many types of chronic infection.

(2) It is almost totally nonirritating to living tissue.

(3) It is mildly bactericidal to many forms of organisms, especially those producing putrefaction.

(4) It almost immediately eradicates all odor without producing another odor.

(5) It is inexpensive.†

* We have adopted the suggestion of a recent reviewer,[3] in electing to use the chemical term carbamide, because of the suggested association in the minds of some of the term urea with urine, and also because this substance is now prepared synthetically.

† We are indebted to Rare Chemicals, Inc., of Nepara Park, N. Y., for trial supplies of "eucupin" dihydrochloride.

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These good qualities, which are approximately the same as those which were pointed out in our initial report,[4] have been supported by all of the observations which we have made since that time. However, two problems have arisen in connection with the use of carbamide. One of these has to do with the physical nature of the material applied to the wound. When we first used carbamide it was applied either in a strong, usually saturated, aqueous solution or in the crystalline form depending on the degree of moistness of a wound. The solution was naturally the method of application of choice in any fistulous wound. Mertins has used it in the aural canal for the treatment of chronic otitis media. In many other areas, the solution could be employed, but we have generally preferred the crystals, when their application was possible. Their chief disadvantage is their tendency to dry out and cake on occasion, and the difficulty of maintaining them in proper contact with the tissue at times. To obviate these difficulties we have compounded a urea paste for occasional use, the preparation of which is described below.

The other problem which we recognized in our early work and which has become important enough to warrant an attempt to obviate it, is the pain which is incident to the use of carbamide in some cases. This is due to the fact that hypertonic solutions may be painful to denuded tissues. Of such origin, is the aggravated pain of an aching tooth when candy is dissolved in the mouth. After a trial of many local anesthetics, a product has been found which is not only effective in almost all cases, on mucosa as well as denuded areas, but also has a useful bactericidal action.[7] This is iso-amyl-hydrocupreine, which is known as "eucupin." Although originally synthesized as a bactericidal substance, its high potency as a local anesthetic has made it even more useful.[8, 9] The prolonged anesthesia which results has been particularly useful for our purpose. Since the free base is not water soluble, "eucupin" dihydrochloride is the compound ordinarily utilized. We have mixed this compound with the crystals of carbamide or added it to the solution in a concentration of 0.4–0.5 per cent. It may also be incorporated in the carbamide paste, which is composed of: Carbamide 50.0 per cent, karaya gum 2.5 per cent, eucupine 0.5 per cent, and is compounded as follows:

Five hundred Gm. of carbamide* (crystal urea, DuPont) are dissolved in approximately 300 cc. of hot water. Half of this solution is then placed in another container and 25 Gm. of powdered first grade gum karaya (India gum) are dissolved in it by vigorous stirring. The resulting paste is then sterilized by autoclaving. To the other portion of carbamide solution 5 Gm. of "eucupin" dihydrochloride are added and this mixed with the autoclaved carbamide-gum karaya solution, and made up to a final volume of 1,000 cc. This solution on cooling is ready for use.

It has been our practice to treat all infected and, occasionally, some rel-

* Carbamide may be purchased from most chemical houses. A very pure product, which may be obtained at low cost, in quantities of 100 pounds, is crystal urea, manufactured by E. I. DuPont de Nemours & Company, of Wilmington, Del.

atively fresh wounds containing dead tissue, until clean, with carbamide crystals, strong carbamide solutions or the paste. Whether or not the "eucupin" dihydrochloride is added depends upon the pain it causes in the wound, and the type of patient. When the wound is clean and granulating, epithelialization is often completed with other dressings. A word should be said concerning the type of granulation tissue which is obtained by employing carbamide therapy. It is far superior to that which results from the application of many antiseptics or occurs in the presence of infection. The carbamide granulation tissue is healthier and more highly vascularized. It is pink, flat, and ideal for skin grafting. The following cases are presented to demonstrate the principles of carbamide application.

## ILLUSTRATIVE CASE REPORTS

**Case 1.**—No. 66256: J. W., male, age 37, entered Scripps Memorial Hospital December 30, 1936, with typical signs and symptoms of a lobar pneumonia of the right lower lobe. For the first twelve days, although acutely ill, the patient seemed to hold his own. On the twelfth day, his condition was definitely worse with rising temperature, and with clinical and roentgenologic evidence of pyopneumothorax. Aspiration at this time recovered 400 cc. of grayish, foul smelling pus, suggestive of lung abscess or anaerobic infection such as is occasionally found following the rupture of a superficial lung abscess into the pleural cavity. Because of the danger of a serious cellulitis of the chest wall with repeated aspiration, immediate open thoracotomy was performed. Under local anesthesia, the eighth rib was resected in the posterior axillary line for a distance of three inches. A large caliber, two-way rubber tube was fastened into the wound for irrigation and drainage. Following the evacuation of a large amount of foul pus, the cavity was irrigated with saturated carbamide solution which was repeated every four hours. There was no evidence of pleurobronchial fistula, but had there been, the use of urea would not have presented such a complication as does Dakin's solution in these cases, as it is not so irritating to the bronchial mucosa. The purulent drainage was deodorized within a few hours—a very helpful property of urea in all foul smelling infections. The clinical course from the time of the thorocotomy showed progressive improvement, the temperature gradually subsiding in two weeks' time, and the patient discharged home, ambulatory, in 21 days, the wound draining very little.

We feel that saturated carbamide solution is far superior to Dakin's solution as an irrigating fluid in empyemata. Its greater lytic properties are more efficient particularly in the anaerobic type of infections, such as detailed above, where control of the infection is directly dependent upon elimination of necrotic tissue on which the bacteria are dependent for their existence. Saturated carbamide solution may best be employed in intracavity infections such as empyemata, nasal sinuses and chronic otitis media; fistulous tracts, as in chronic osteomyelitis; postoperative rectal fistulectomy; ischiorectal abscess cavities; and in deeply infected wounds where the crystals cannot be effectively applied as in deep traumatic wounds and postoperative infected wounds such as the perineal wound following resection of the rectum.

The following case demonstrates the lytic action of carbamide in crystalline form. At no time did the patient complain of discomfort.

**Case 2.**—No. 9400: F. W., female, age 23, was admitted to the Scripps Memorial Hospital January 3, 1938, with a history of increasing pain and tenderness over the

sacral region for the preceding four days. Examination showed a healthy adult female whose clinical and laboratory findings were both normal other than the localized painful area. Inspection here revealed a large, tender, indurated, erythematous area. The infection seemed deep and there was no localization suggestive of a furuncle or carbuncle. An exploratory operation, January 5, 1938, demonstrated a large, thickened, infected pilonidal cyst, which was removed by careful dissection down to the posterior sacral attachments. The wound was packed with carbamide crystals and no attempt at closure made. Any remaining necrotic or inflammatory tissue was promptly removed by the carbamide, and the wound rapidly granulated up from the bottom and healed without complications. The tendency for recurrence due to leaving behind a portion of the cyst wall is well known. The use of carbamide with its strong, lytic action on devitalized tissue, is a great aid in cleaning up such a wound and keeping it clean for normal reparative processes and thus reducing the chance of recurrence.

Case 3 demonstrates the use of the carbamide "eucupin" water-soluble paste, necessitated by the pain resulting from application of the crystals.

**Case 3.**—M. G., female, received a third degree burn, November 16, 1937, involving the entire lateral surface of the left thigh from the knee joint to above the iliac crest extending anteriorly to the middle of Poupart's ligament and thence down the anterior surface of the thigh in this same line. The posterior surface of the thigh was involved for about an inch past the junction of the posterior with the lateral surface. This wide area had been treated with tannic acid in the usual manner, but subsequent infection of the burned surface had undermined the crust which had separated in some areas and from such denuded surfaces large amounts of purulent exudate were discharged. The patient had a septic fever with associated constitutional symptoms. On December 4, 1937, dry carbamide crystals were generously applied, and in less than a week's time the majority of the crust and underlying necrotic tissue had been removed. The carbamide crystals then became so painful that the carbamide paste with "eucupin" dihydrochloride was applied. This was well tolerated and very efficacious. Continued use of this paste for two weeks produced a very clean, healthy, granulating surface, ideal for skin grafting. Since the patient was unable to enter the hospital at this time treatment of the burned area was continued with an epithelializing agent and subsequent skin grafting was successful.

The following two cases are presented to illustrate the use of carbamide crystals in traumatic wounds and to demonstrate that the compound may often be applied without discomfort as well as to remove the fear that carbamide may have a deleterious effect on tendons. The blood supply of tendons is notably less than in many other tissues, but in our experience with a number of cases in which tendons were directly exposed to the action of carbamide, even in the presence of suturing and traumatization, we have seen no evidence of a harmful effect.

**Case 4.**—No. 9224: R. G., male, age 4, entered the hospital October 29, 1937, with the history that while playing in the street he was struck and run over by a heavy truck, sustaining a severe injury to the left foot. Physical examination revealed moderate shock as evidenced by pallor, rapid pulse and respirations. There was no evidence of injury other than to the left ankle except subcutaneous emphysema involving the left chest wall and the left side of the neck. Roentgenologic examination showed no evidence of fractured ribs and the laboratory findings were normal. The patient's condition improved after antishock measures were applied and the injured ankle was inspected under ethylene anesthesia. Over the anterior aspect of the left ankle joint the skin was absent as a result of a grinding force which had completely denuded an area two inches in

diameter. It appeared as if the foot had been placed on an emery wheel and a complete section of the soft tissues ground out, including skin, subcutaneous tissue, fascia cruris, sections of the tendons, extensor digitorum longus, hallucis longis and tibialis anticus, together with the dorsalis pedis artery and accompanying nerve, ligaments attached to the anterior surface of the talus and the entire articular surface of the talus. The roentgenogram showed the superior margin of the talus ground off so that the articular surface presented a straight line. Operation consisted of débridement of all obviously devitalized tissue. Skin edges were freed and dissected back with the aid of extending incisions above and below. Blood vessels were ligated and repair of the three extensor tendons carried out with lengthening due to loss of substance. The skin defect could not be entirely closed because of the marked tissue loss, but was approximated as well as possible and the foot immobilized at a right angle in a molded plaster splint. At the first dressing, three days later, there was considerable purulent discharge from the wound, and carbamide crystals were introduced generously. The foot was kept immobilized, with only the application of carbamide crystals at the time of the daily dressings. In six weeks the plaster splint was removed, and over the following two weeks gradual weight bearing was allowed with the aid of crutches. The wound was still draining slightly from a small central sinus but in eight weeks' time was entirely healed and the extensor tendons were functioning normally. A mild, acquired talipes valgus was corrected with a leather anklet and arch support, which gave a normally functioning foot.

In this case, as in many others, carbamide was employed without discomfort. In a child with a seriously contaminated, traumatic wound involving soft tissue, tendons, blood vessels, bone and joint surfaces with following infections, deterrents to wound healing were so satisfactorily controlled by the application of carbamide crystals that no injury to the tendon repair occurred, and no serious osteomyelitis developed, leaving an ankle joint without dysfunction. The following case is also a typical example of the good results obtained with carbamide in traumatic injury, involving in addition the presence of gross infection.

**Case 5.**—J. J. L., male, age 45, was first seen at the office October 18, 1937, stating that he had crushed his hand with an air jack hammer while straightening a piece of steel. Examination revealed a three inch laceration on the palmar surface of the right index finger extending from the tip of the distal phalanx to the second palmar crease. The wound was jagged and the adjoining tissues were badly crushed. In addition to the soft tissue injury, there was fragmentation of the bones of the index and second fingers as well as a dislocation of the second phalanx of the first finger. The flexor tendons were exposed throughout the length of the laceration. The wound was débrided under regional anesthesia, the edges sutured as well as possible, and the hand placed on a molded plaster splint. By the third postoperative day, a gross infection developed in the flexor tendon sheath; the wound was opened and packed with carbamide crystals. This was done daily for four days, at the end of which time the wound was clean and granulating. In 10 days' time the wound was completely healed, although traction was maintained on the finger for three weeks, and this was followed by appropriate physiotherapy. Considering the serious tendon sheath infection, the result was excellent, for the only residual disability was a slight limitation of the motion of the second phalanx.

We are still of the opinion that, although the mild bactericidal action of carbamide is of some consequence, the chief value of the compound in wound healing is due to its remarkable solvent action on protein compounds. As Mertins[6] concludes from his experience with carbamide in chronic otitis media,

"the results are simply due to a more adequate removal of the gross and microscopic débris in the recesses of the middle ear, giving nature a fair chance, often with surprisingly successful results." Dilute urea solutions also continue to be used[10, 11] with the idea that they stimulate cell proliferation in wound healing.[12] That they give a slight degree of success we cannot deny, and as we have already pointed out this is probably due to the long known activity of dilute urea solutions in promoting proteolysis of the necrotic tissue.[13] Support is given to this view by a recent study[14] demonstrating that dilute urea solutions are without influence upon the rate of growth of fibroblasts in tissue culture. It is true that there is some evidence[15] that dilute urea solutions produce proliferation of capillaries by sprouting and may thus aid in wound healing. However, we prefer to avoid dilute urea solutions because of the excellent medium for bacterial growth which they provide and the superior results obtained with higher concentrations.

SUMMARY

The efficacy of carbamide (urea) as an adjunct to wound healing, due primarily to the lytic action of strong aqueous solutions upon necrotic tissue and other débris, is again demonstrated. Details of the practical application of carbamide therapy are outlined.

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# GAS GANGRENE*

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After my experience in the Evacuation Hospitals of the A.E.F. I thought I was thoroughly competent to diagnose and treat patients with gas gangrene, but, just one year ago, I lost a patient from this condition, and then I realized that I knew very little about the present-day diagnosis and treatment of gas bacillus infection. I, at once, began to review the literature extensively. My opinion is that probably all the papers on this subject written before 1934 are worthless for clinical purposes. However, an article, by Eliason,[1] in 1937, is most comprehensive and instructive.

Gas bacillus infections occur in all sections of the United States. In some localities it is far more prevalent than in others. In my section—Chattanooga—it is very rare. The Baroness Erlanger Hospital, a 200 bed municipal hospital in Chattanooga, reports no cases during the period 1926–1934, and only two cases each in 1935–36–37–38. Of the eight cases reported by Erlanger Hospital, three were gunshot wounds, three were compound fractures, one a crushed arm, and one an abscess over the orbit. In over 42,000 traumatic cases treated at our clinic during the past 21 years, our records show only five cases of gas bacillus infection—one severe trauma to the leg, one compound fracture, two gunshot wounds, and one avulsion of the arm. In 257 major compound fractures during the past 12 years, there has been only one case of gas gangrene.

Millar[2] records a series of 607 cases occurring in civil life, which is probably only a small percentage of the cases of gas bacillus infection that did develop during that period—the others were not reported.

Junghous, in 1933, analyzed more than 60 cases of gas gangrene following hypodermic medication of all types, of which only four survived. Boland, of Atlanta, says: "In 80 cases of compound fractures, occurring in Negroes, 15, or 19 per cent, developed gas gangrene; whereas, in the same period, in 97 cases of compound fractures, occurring in white, 7 per cent developed gas gangrene."

Eliason[1] says that at the University of Pennsylvania and Philadelphia General Hospitals, the incident of gas gangrene following amputation for diabetic gangrene, senile gangrene, and Buerger's disease was 6.8 and 10 per cent, respectively.

In our clinic, over 100 amputations for arteriosclerotic and diabetic gangrene have been performed and no case of gas gangrene has been recorded. Evidently this porous, sandy, hilly soil does not harbor anaerobic organisms to the same extent that a flat country does. Cultures and smears from the

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wounds and skin of the patients who come to our clinic are rarely positive for the anaerobic organisms. Cultures from the battlefields of France, as well as from the uniforms on men returning from the trenches, were 100 per cent positive for anaerobic organisms, according to records from the Surgeon General's office.

In civil life, chronic leg ulcers have shown 34.3 per cent positive. Roberts, Johnson,[3] and Brickner[4] were able to cultivate it from the skin of 21.7 per cent of unprepared abdomens, 8.5 per cent of knife blades used in making skin incisions, and 9.2 per cent from the peritoneum when opened for noninflammatory conditions. Gamble reported 12 cases of emphysematous gangrene of the abdominal wall which he has had in his practice since November, 1923—all of these cases followed operation for ruptured, gangrenous appendicitis.

There have been about 25 varieties of anaerobic organisms isolated. *Clostridium welchii* is present in from 80 to 90 per cent; *Clostridium oedematis maligni* or vibrion septique of the French, 10 to 20 per cent; *Clostridium oedematiens* about 5 per cent.

The usual prophylactic polyvalent dose is 1,500 units of tetanus antitoxin, 2,000 units of *Clostridium welchii* antitoxin, and 2,000 units of *Clostridium oedematis maligni*. The usual therapeutic dose, called polyvalent gas gangrene antitoxin, comprises the following in one vial: 10,000 units *Clostridium welchii*, 10,000 units *Clostridium oedematis maligni*, 2,500 units *Clostridium histolyticum*, 1,000 units *Clostridium oedematiens*, and 200 units oedematoids. This combination contains antitoxin specific for all the toxin-producing, spore-forming anaerobes now credited with causing gas gangrene in man.

*Diagnosis.*—It has been thought for years that crepitation in the tissue was the first symptom that caused one to suspect gas gangrene. It is now known that we must make the diagnosis of gas bacillus infection before crepitation is perceptible, or we lose the precious early hours of the infection when proper management will give a mortality of from 5 to 15 per cent instead of the usual mortality of from 49 to 80 per cent.

It is so usual to read the statement that the positive diagnosis of the contaminating agent is made by smears and cultures! The positive findings by smear may mean nothing, as Evacuation Hospital No. 8 of the A.E.F. reported 890 wound cultures of which 478, or 53 per cent, contained anaerobic bacilli; of these 478 wounds, 67 per cent at no time showed evidence of gas gangrene. To await the result of culture before making a diagnosis is too late. The diagnosis must be suspected when a patient who has a wound that has been contaminated with soil, feces, or dirty clothing suddenly complains of severe pain in the wound, when the pulse rate is higher than the temperature would indicate, and inspection of a previously closed wound reveals edema and brownish discoloration of the skin. If not closed, the wound is dirty in appearance and there is a discharge of brownish serum, and, at times, a mousy, offensive, or putrid odor, or there may be scarcely no odor. If, in addition to the above signs and symptoms, a roentgenogram shows gas bubbles in the tissue, active treatment should be begun at once.

Rinehart was first to call our attention to the value of the roentgenogram in making a diagnosis before the infection is clinically apparent. In suspected cases a roentgenogram should be made every four hours. If there is an increase in the number of air bubbles in each succeeding film, then we know that the bubbles are not due to air that has been forced into the tissue by muscle action at the time of the injury. Too, the gas in the tissue may be due to colon bacillus infection. The roentgenologic diagnosis is usually many hours ahead of the clinical diagnosis, and an early diagnosis is of supreme importance.

If the infection is due to vibrion septique, no crepitation will be found on palpation and no gas bubbles will be found roentgenologically. The diagnosis will be made by the very marked edema. Ghormley[5] reports such a case in his series of 43 cases from The Mayo Clinic.

Frequent inspection of the patient and the wound is of extreme importance during the early stages. Early recognition is the most important step in treatment and is not difficult if the possibility of gas gangrene is kept constantly in mind.

*Treatment.*—The most important factor in the treatment is the recognition that where muscle tissue is mangled and the blood supply is gravely damaged, one has the ideal culture medium for the growth of anaerobic organisms and that without this condition the presence of these organisms should give us but little concern.

Since our war service, it has been our practice to clean wounds with soap and water, to undertake a meticulous débridement whenever soft parts have been mangled, to control bleeding by direct attack, and not to stop bleeding by packing the wound, thus further impairing the blood supply. If débridement and hemostasis are satisfactory and the wound can be closed without tension, then the wound is closed without drainage. At the State Hospital in Shreveport, Louisiana, the incidence of gas bacillus infection has been greatly reduced by not closing such wounds.

During the past 10 years, we have used combined prophylactic tetanus and gas gangrene antitoxin whenever the wound has been greatly traumatized and grossly contaminated with soil, *etc.* In four of the five cases occurring in our clinic, the prophylactic antitoxin was administered; the first, or other case, occurred before we had begun the routine use of the prophylactic antitoxin. However, during the 20 years previous to the past 10 years, no prophylactic dose was administered and only one case is recorded during that 20-year period. Erlanger Hospital, of Chattanooga, did not use prophylactic injections during the same period and although with a greater number of traumatic cases treated, had no case of gas gangrene for nine years. It is generally concluded that the prophylactic injection does not prevent gas bacillus infection, but that it probably lengthens the incubation period and lessens the severity of the attack, and that it should be given on three successive days.

Veal,[6] of New Orleans, says: "There were two deaths among the 27 patients who had received the prophylactic antitoxin, a mortality of 7.4 per

cent; while there were 13 deaths among the 27 who did not receive it, a mortality of 48 per cent. Furthermore, in the group of 10 patients treated by débridement, all of whom received prophylactic antitoxin, there was only one death and this patient was almost moribund when he was first seen."

It is widely practiced and generally believed that early thorough débridement is the surest preventive against gas gangrene and one of the most important measures to stop the spread of the infection after it has begun. The débridement must consist of an amputation if the blood supply has been greatly damaged; and this must be performed early and should be, of course, of the guillotine type. If the blood supply is fair to good, then under the modern treatment an amputation will probably not be necessary.

From our own experience and from the literature, the one most important therapeutic agent is the early intravenous administration of 10,000 to 30,000 units of polyvalent antitoxin, repeated every six to eight hours. Bohlman,[8] of Johns Hopkins, has suggested the use of sulfanilamide for both prophylaxis and therapeusis.

The Surgeon General's report calls attention to symbiosis of various aerobes and anaerobes. In Base Hospital No. 15, A.E.F., in 73 cases of gas gangrene with death, activity of gas bacilli was self-limiting and probably confined to the first week after the wound was received, with a drop in anaerobes from 38 to 7 per cent during the first seven days, as the common pyogens Streptococcus and Staphylococcus accumulated rapidly in the wound. The symbiotic effect was particularly prominent in fatal wounds. For its effects on both aerobes and anaerobes, it should be given in all cases.

Kelly[7] reports 44 cases of gas gangrene of the extremities, treated with roentgenotherapy. There were 29 in which amputation was not performed and all 29 patients recovered. Out of the 15 who had amputation, five died, a mortality of 33.3 per cent. He says further: "In concluding, it seems fair to state that the roentgen ray, up to this time, seems to be definitely established as an aid in the treatment of gas gangrene, both in extremity and in trunk cases, but it seems desirable to use serum and other measures and refrain from amputation until the patient has recovered from shock and from the gas bacillus infection."

For local application or instillation, we formerly always used Dakin's solution by the meticulous method elaborated by Dr. Alexis Carrel, at the Rockefeller Institute, but, judging from the present-day literature, it seems to make little difference whether Dakin's solution, hydrogen peroxide, or 1-500 potassium permanganate is used.

**Case Report.**—On February 6, 1938, I saw a patient in consultation at Dayton, Tenn. Twenty-four hours previously this young man had been shot in the abdomen, on the right side just below the costal arch, with a shotgun. An exploratory celiotomy had been performed almost immediately by Dr. Agnew Thomison; appendicectomy had been performed as the appendix was in the wound. The lower edge of the liver was found lacerated and the anterior surface of the liver was speckled with shot. Multiple shot were in the mesentery and serous coat of intestines; however, no perforation of the intestine was found. The lower intercostal and abdominal muscles of the right side

were torn and lacerated. The wound was closed and a small rubber tissue drain placed under the skin. When first seen, the temperature was 102° F., pulse 124, and the wound was edematous and soggy in appearance and was reddish brown in color; a brownish, offensive serum was exuding between the sutures and from the drain; on palpation, crepitation could be felt for an area of six inches below the wound. When the sutures were removed gas could be seen bubbling up from the wound surfaces and from the area under the intact skin. Remembering Kelly's experience with amputation, I did not advise further incisions to drain the crepitating area. The wound was kept moist with $O_2$ packs and 20,000 units of polyvalent gas gangrene antitoxin were given intravenously immediately, and 120,000 units more were administered over a period of three days.

Sulfanilamide was given in 10 grain doses every four hours for six days. Temperature was normal on February 13, and the sulfanilamide was discontinued. No evidence was present at this time of gas bacillus infection. However, on February 20, two weeks after onset, the temperature rose again; sulfanilamide was reinstituted at four-hour intervals for three days, when the temperature again became normal. Roentgenotherapy was administered twice daily during the first week.

Although this patient was desperately ill with high temperature and was delirious, at the end of the first week he was practically over the gas bacillus infection. The sulfanilamide must have prevented the symbiosis which is so common in these cases.

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DISCUSSION.—DR. J. DUFFY HANCOCK, Louisville, Ky.: I think Doctor Newell's paper is most timely, as well as most interesting. With the advent of high speed transportation I believe we will see many more of these crushing injuries and probably an increase in gas gangrene infections. He has presented an excellent summary of the modern treatment of gas bacillus infection. I would like to report another case—a woman, age 45, whose right forearm was injured in an automobile accident, fell into the hands of an excellent country doctor who cleansed the wound, left it open and gave a prophylactic dose of the combined anti-gas gangrene and antitetanic serum. Twelve hours later she had intense pain in the forearm, with a foul discharge. Twenty-four hours after the injury, when I saw her, there was crepitation to the elbow, a smear was positive for the gas bacillus of Welch and this was confirmed later by culture. We followed essentially the same treatment as Doctor Newell

described, opened the wound and used hydrogen peroxide irrigations, administered the serum, and sulfanilamide, 90 gr. the first day, 60 the second and 30 the third, and administered roentgenotherapy, 120 r. units every day for four days. She went on to a complete recovery.

Just as Doctor Newell said, I believe treatment has been revolutionized in the last few years, and that in the future it will consist of roentgenotherapy, serum, sulfanilamide and irrigations, with hydrogen peroxide being the solution I think is best of all.

DR. RALPH G. CAROTHERS, Cincinnati, Ohio: I agree with everything Doctor Newell has said except as to the use of roentgenotherapy. Doctor Newell pointed out that there was a great deal of gas gangrene in some localities, and in others not so much. I think that is so; the infection is much more virulent in certain parts of the country than in others. In talking to a surgeon from Wyoming, he told me recently that he had not seen a case of tetanus in that part of the country. Of course, tetanus is not gas gangrene, but they are caused by similar organisms. I wonder if Doctor Kelly's work is not based on a type of organism that is prevalent in the dry plains of Nebraska, which are similar to the Wyoming locality I referred to. Doctor Cubbins reported eight cases treated with roentgenray in Cook County Hospital, Chicago, with eight deaths.

In Cincinnati, we have a type of organism that is rather virulent. I saw a case of gunshot wound in the thigh with a compound fracture of the femur. The accident occurred at three o'clock in the afternoon and when the patient was brought in at 6:30, the roentgenogram showed the infection to be already well advanced.

The principal thing in addition to the serum is to decompress the parts and split the fascia on both sides. The gas is like an expanding tourniquet. If you split the fascia on the two sides, expansion can take place without cutting off the blood supply. We did this in this case, and then put the patient in a Thomas splint. The swelling was so great that the thigh bulged over the splint on each side, but the tissues did not become gangrenous and there was no edema below the knee. That man has a good leg today.

DR. GROVER C. WEIL, Pittsburgh, Pa.: The paper presented by Doctor Newell considers a very important factor in traumatic surgery, and certain phases of it have been very interesting from the point of view of treatment. Our experience in gas bacillus infection dates back many years, in view of the large number of traumatic cases we have had on the service of the Pittsburgh Coal Company.

The advances made in the treatment of such infections, as I review them, seem almost like a romance in surgery, dating back to the days when immediate amputation was found necessary in order to save the life of the patient, and up to the present date with the use of antitoxin as one of the important therapeutic measures. The heavier mortality in the older days seems to have been due to lack of proper understanding in diagnosis.

A great factor in the saving of lives at the present time on our service is the early recognition of the condition and the immediate institution of surgical measures. One important diagnostic feature, as we instruct our medical students, is the value of detecting a "sour-sweet" smell which emanates from the wound and which can be detected early when one becomes familiar with the odor. On many occasions the nurses have reported its presence, which always serves as an indication for an immediate examination of the wound, and one can then observe the physical changes indicating the infection. I feel that many lives have been saved as the result of the early detection of this

diagnostic sign. Surgical measures are immediately instituted in the way of large incisions and proper drainage, followed by the application of huge wet compresses far beyond the site of the lesion, using as a rule magnesium sulphate. We immediately administer huge doses of antitoxin, which has proved of utmost value on our service.

With reference to the advantages of roentgenotherapy, I may say that our experience has been rather limited and I would rather hesitate to rely solely upon its administration as a therapeutic measure, in view of its terrific virulence and the powerful invasive properties of certain of these organisms. As a preliminary measure, however, until the patient can be transported to a suitable institution where proper therapy can be instituted, one may be justified in its application.

Dr. E. Dunbar Newell, Chattanooga, Tenn. (closing): I reported one case where I did not use an incision to relieve the tension. That has always been my practice. In war surgery we had to do that, but in this particular case I thought if Kelly had the same kind of organism that we had and reported such wonderful results, I would give it a trial. I did so, and while one case does not mean anything it seemed to be very effective. These are desperate cases, and patients are in profound shock when they get this infection, and maybe we do harm by further manipulation.

My purpose was to bring out that this treatment which is so effective in the hands of a few men might be used by many more. After all, none of our old methods was very effective. I agree with Doctor Carothers as to the virulence of the organisms. In our particular section we do not see so much of it, and in other sections it is very common.

Before reading the recent literature, I thought I was well qualified to both diagnose and treat gas bacillus infections, but after I had concluded my reading I was amazed to find out how little I knew about the modern methods of drugs and treatment.

# FRACTURES AND DISLOCATIONS BY MUSCULAR VIOLENCE, COMPLICATING CONVULSIONS INDUCED BY METRAZOL FOR SCHIZOPHRENIA*

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THE MONTHLY REPORT to the Board of Visitors of the Rockland State Hospital for May, 1938, mentioned a fractured neck of a femur in a female schizophrenic, age 30, which had been produced by the muscular violence of a convulsion induced by metrazol. This injury seemed so severe and unusual that statistics on similar injuries were obtained from the 20 New York Civil State Hospitals according to a definite scheme of study (Table I). These statistics are analyzed in Table II, and they indicate that the complicating injuries must be seriously considered in appraising the value of metrazol therapy.

It is clearly not within the scope of this paper to give the clinical features or treatment of the injuries. Suffice it to say that 687 patients had metrazol therapy one or more times, and that 12 fractures (1.78 per cent) and 118 dislocations (17.2 per cent) occurred in these patients as complications of the convulsions. In terms of the total number of convulsions (859) in all the patients up to the time of injury, the fractures constituted 1.5 per cent and the dislocations 13.9 per cent.

In no instance was there any external violence, such as an injury sustained by falling out of bed. In every case, the injury was produced entirely by the muscular violence of the convulsion.

By comparison, the convulsive state produced by epilepsy shows that none of the injuries under discussion have occurred at the Rockland State Hospital during the past three years. During this time, the average number of epileptics under observation monthly was 30, and these patients had an average number of 213 convulsions monthly.

A few psychiatrists mention injuries of the same nature: Finkelman, Steinberg and Liebert[1] report "minor complications such as dislocation of the mandible and dislocation of the head of the humerus"; Nightingale[2] reports a "fractured femur"; Dhunjibhoy[3] reports one dislocated shoulder in 12 cases treated; and Lebensohn[4] reports "dislocation of the shoulder."

*History of Shock and Convulsion Therapy.*—In 1933, Sakel[5] described the treatment of morphine addiction by the use of massive doses of insulin with its resulting hypoglycemia. In 1934, he[6] described the insulin hypoglycemic shock therapy for schizophrenia. The treatment "grew out of the

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* 1,404 patients had insulin therapy. One sustained a dislocation of the mandible, three had dislocations of the head of the humerus, and one had a fracture of the greater tuberosity of the humerus, all the result of muscular violence during a hypoglycemic convulsion. These cases are included in Table I.

TABLE I

STATISTICAL DATA IN 13 FRACTURES AND 120 DISLOCATIONS PRODUCED BY MUSCULAR VIOLENCE OF CONVULSIONS DURING METRAZOL AND INSULIN THERAPY

| Name of State Hospital | Total Number of Patients Treated | | Initials of Patients | Sex | History Number | Age | Number of Convulsions Previous to Injury | Duration of Convulsive Seizure Producing Fracture or Dislocation | Type of Restraint | Anatomic Diagnosis |
|---|---|---|---|---|---|---|---|---|---|---|
| | Metrazol | Insulin | | | | | | | | |
| Binghamton.. | 37 | 70 | S. H. C. | M. | 228552 | 33 | 4 | 50 secs. | None | Fracture anatomic neck humerus, fracture greater tuberosity, posterior dislocation head |
| Brooklyn..... | 343 | 251 | T. L. | F. | 55843 | 38 | 6 | 46 secs. | None | Anterior dislocation head humerus |
| | | | E. J. | F. | 54956 | 27 | 6 | 45 secs. | None | Anterior dislocation head humerus |
| | | | L. O. | M. | 46035 | 33 | 15 | 50 secs. | None | Intracapsular fracture neck femur |
| | | | S. L. | M. | 52825 | 24 | 16 | 50 secs. | None | Intracapsular fracture neck femur |
| | | | H. B. | M. | 42530 | 26 | 4 | 70 secs. | None | Dislocation mandible |
| | | | E. C. | M. | 52488 | 23 | 15 | 46 secs. | None | Dislocation mandible |
| | | | J. D. | M. | 52692 | 22 | 0 | 48 secs. | None | Dislocation mandible |
| | | | B. S. | M. | 55347 | 35 | 22 | 54 secs. | None | Dislocation mandible |
| | | | A. O. | M. | 48502 | 30 | 0 | 57 secs. | None | Dislocation mandible |
| | | | R. M. | M. | 53220 | 19 | 13 | 50 secs. | None | Dislocation mandible |
| | | | F. L. | M. | 50440 | 33 | 0 | 52 secs. | None | Dislocation mandible |
| | | | M. J. | M. | 50453 | 25 | 0 | 45 secs. | None | Dislocation mandible |
| | | | A. C. | F. | 51597 | 28 | 7 | 48 secs. | None | Dislocation mandible |
| | | | K. F. | F. | 51898 | 32 | 14 | 54 secs. | None | Dislocation mandible |
| | | | E. K. | F. | 51473 | 30 | 1 | 45 secs. | None | Dislocation mandible |
| | | | I. S. | F. | 55215 | 25 | 2 | 50 secs. | None | Dislocation mandible |
| | | | A. S. | F. | 41391 | 33 | 1 | 47 secs. | None | Dislocation mandible |
| | | | E. S. | F. | 54380 | 20 | 1 | 45 secs. | None | Dislocation mandible |
| | | | A. C. | M. | 54869 | 24 | 0 | 36 secs. | None | Dislocation mandible |
| | | | A. C. | M. | 54869 | 24 | 2 (insulin) | 63 secs. | None | Dislocation mandible |
| Buffalo..... | 35 | 86 | E. M. | F. | 24346 | 31 | 21 | 1 min. | None | Dislocation head right humerus |
| | | | E. M. | F. | 24346 | 31 | 31 | 1 min. | None | Dislocation head left humerus. Dislocation mandible 12 times |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | C. J. | M. | 25561 | 24 | 6 | 1 min. 40 secs. None — Dislocation mandible 7 times in 7 convulsions |
| | | | J. M. | M. | 25697 | 44 | 7 | 1 min. 10 secs. None — Dislocation head humerus |
| Central Islip.. | 25 | 111 | G. M. | M. | 23666 | 27 | 10 | 1 min. 50 secs. None — Dislocation head humerus |
| | | | M. D. | M. | 29581 | 34 | 0 | 1 min. 20 secs. None — Intracapsular fracture neck femur |
| | | | G. A. P. | M. | 27969 | 36 | 4 | 1 min. None — Intertrochanteric fracture neck femur |
| | | | J. B. | M. | 32777 | 32 | 33 | 1 min. None — Fracture greater and lesser tuberosity humerus |
| | | | V. B. | F. | 23546 | 20 | 0 | 1 min. None — Dislocation mandible |
| | | | V. B. | F. | 23546 | 20 | 13 | 1 min. None — Dislocation mandible |
| | | | N. F. | M. | 32070 | 21 | 3 | 1 min. None — Dislocation mandible |
| Creedmoor... | 33 | 53 | J. T. | M. | 291938 | 30 | 7 | 50 secs. None — Fracture anatomic neck humerus |
| | | | D. B. | M. | 239618 | 26 | 2 | 45 secs. None — Dislocation mandible |
| | | | M. P. | M. | 304992 | 28 | 1 | 54 secs. None — Dislocation mandible |
| | | | M. P. | M. | 304992 | 28 | 2 | 56 secs. None — Dislocation mandible |
| | | | M. P. | M. | 304992 | 28 | 3 | 51 secs. None — Dislocation mandible |
| | | | F. J. E. | M. | 291940 | 30 | 0 | 54 secs. None — Dislocation mandible |
| Gowanda..... | 41 | 35 | W. G. | M. | 258792 | 28 | 10 | 2½ mins. None — Dislocation mandible |
| | | | E. H. | M. | 269314 | 30 | | None — Dislocation mandible |
| | | | G. K. | M. | 238614 | 30 | 0 | None — Dislocation head humerus |
| | | | H. H. | M. | 288689 | 37 | 1 | None — Dislocation head humerus |
| Harlem Valley | 11 | 126 | R. V. L. | M. | 284654 | 23 | 33 | ½ min. None — Anterior dislocation head humerus |
| | | | M. G. | M. | 307391 | 33 | 21 | 45 secs. None — Compression fracture body seventh thoracic vertebra, dislocation mandible |
| | | | I. S. | F. | 306461 | 38 | 26 | 1 min. None — Fracture transverse processes fifth lumbar vertebra |
| | | | H. F. | F. | 35608 | 22 | 1 | 2 mins. Manual — Dislocation head humerus |
| | | | B. C. | F. | 33149 | 40 | 0 | 1 min. 30 secs. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 6 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 9 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 11 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 12 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 13 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 14 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 16 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 19 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 21 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 22 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 23 | 1 min. Manual — Dislocation mandible |
| | | | B. C. | F. | 33149 | 40 | 24 | 1 min. Manual — Dislocation mandible |

TABLE I—(*Continued*)

| Name of State Hospital | Total Number of Patients Treated | | Initials of Patients | Sex | History Number | Age | Number of Convulsions Previous to Injury | Duration of Convulsive Seizure Producing Fracture or Dislocation | Type of Restraint | Anatomic Diagnosis |
|---|---|---|---|---|---|---|---|---|---|---|
| | Metrazol | Insulin | | | | | | | | |
| | | | B. C. | F. | 33149 | 40 | 26 | 1 min. | Manual | Dislocation mandible |
| | | | R. T. | F. | 32372 | 33 | 0 | 1 min. | Manual | Dislocation mandible |
| Kings Park... | 1 | 96 | F. A. | M. | 275165 | 25 | 7 | 52 secs. | None | Fracture angle mandible |
| Manhattan... | 13 | 35 | R. S. | F. | 93943 | 28 | 2 | 65 secs. | None | Dislocation mandible |
| | | | J. C. | M. | 101026 | 26 | 0 | 95 secs. | None | Dislocation mandible |
| Marcy..... | 17 | 52 | A. B. | F. | 308735 | 33 | 2 | 1 min. | Partial, freedom of extremities | Dislocation mandible |
| | | | C. D. | F. | 307574 | 28 | 3 | 1 min. | Partial, freedom of extremities | Dislocation mandible |
| Psychiatric Institute..... | 0 | 82 | I. H. | M. | 1642 | 33 | 1 (insulin) | 45 secs. | None | Dislocation head humerus |
| Rockland.... | 102 | 53 | J. U. | M. | 8690 | 28 | 0 | 1 min. | None | Anterior dislocation head humerus, fracture greater tuberosity |
| | | | R. S. | F. | 867 | 30 | 2 | 1 min. | Light protection sheet | Fracture neck femur |
| | | | H. N. | F. | 11592 | 31 | 7 | 1 min. | None | Anterior dislocation head humerus |
| | | | F. G. | M. | 10162 | 29 | 0 | 55 secs. | None | Dislocation mandible |
| | | | F. G. | M. | 10162 | 29 | 1 | 55 secs. | None | Dislocation mandible |
| | | | F. G. | M. | 10162 | 29 | 4 | 55 secs. | None | Dislocation mandible |
| | | | V. B. | M. | 11253 | 25 | 10 | 1 min. | None | Anterior dislocation head humerus |
| | | | L. H. | M. | 5434 | 26 | 1 | 55 secs. | None | Dislocation mandible |
| | | | L. H. | M. | 5434 | 26 | 2 | 55 secs. | None | Dislocation mandible |
| | | | L. H. | M. | 5434 | 26 | 3 | 55 secs. | None | Dislocation mandible |
| | | | L. H. | M. | 5434 | 26 | 4 | 55 secs. | None | Dislocation mandible |
| | | | L. H. | M. | 5434 | 26 | 5 | 55 secs. | None | Dislocation mandible |
| | | | J. N. | M. | 9859 | 23 | 0 | 55 secs. | None | Dislocation mandible |
| | | | J. N. | M. | 9859 | 23 | 1 | 55 secs. | None | Dislocation mandible |
| | | | J. N. | M. | 9859 | 23 | 9 | 55 secs. | None | Dislocation mandible |
| | | | J. N. | M. | 9859 | 23 | 14 | 55 secs. | None | Dislocation mandible |
| | | | J. N. | M. | 9859 | 23 | 19 | 55 secs. | None | Dislocation mandible |
| | | | A. S. | M. | 5769 | 33 | 0 | 55 secs. | None | Dislocation mandible |
| | | | A. S. | M. | 5769 | 33 | 10 | 55 secs. | None | Dislocation mandible |
| | | | A. S. | M. | 5769 | 33 | 20 | 55 secs. | None | Dislocation mandible |

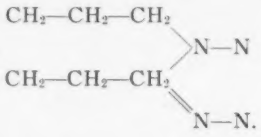
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A. S. | M. | 5769 | 33 | 10 | | 55 secs. | None | Dislocation mandible | | |
| A. S. | M. | 5769 | 33 | 20 | | 55 secs. | None | Dislocation mandible | | |
| T. B. | F. | 2218 | 26 | 0 | | 65 secs. | None | Dislocation mandible | | |
| T. B. | F. | 2218 | 26 | 2 | | 65 secs. | None | Dislocation mandible | | |
| T. B. | F. | 2218 | 26 | 6 | | 65 secs. | None | Dislocation mandible | | |
| T. B. | F. | 2218 | 26 | 8 | | 65 secs. | None | Dislocation mandible | | |
| B. M. | F. | 11781 | 21 | 8 | | 50 secs. | None | Dislocation mandible | | |
| M. W. | F. | 10885 | 23 | 0 | 1 min. | | None | Dislocation mandible | | |
| M. W. | F. | 10885 | 23 | 18 | 1 min. | | None | Dislocation mandible | | |
| P. J. | M. | 11540 | 18 | 0 | | 45 secs. | None | Dislocation mandible | | |
| C. M. | M. | 944 | 17 | 6 | | 55 secs. | None | Dislocation mandible | | |
| S. M. | M. | 6853 | 19 | 3 | | 55 secs. | None | Dislocation mandible | | |
| S. M. | M. | 6853 | 19 | 14 | | 55 secs. | None | Dislocation mandible | | |
| J. S. | M. | 12184 | 30 | 0 | | 55 secs. | None | Dislocation mandible | | |
| J. S. | M. | 12184 | 30 | 5 | | 55 secs. | None | Dislocation mandible | | |
| S. B. | F. | 12146 | 20 | 19 | | 40 secs. | None | Dislocation mandible | | |
| M. D. | F. | 11339 | 23 | 0 | | 45 secs. | None | Dislocation mandible | | |
| M. D. | F. | 11339 | 23 | 1 | | 45 secs. | None | Dislocation mandible | | |
| M. D. | F. | 11339 | 23 | 4 | | 45 secs. | None | Dislocation mandible | | |
| M. D. | F. | 11339 | 23 | 6 | | 65 secs. | None | Dislocation mandible | | |
| M. D. | F. | 11339 | 23 | 15 | | 65 secs. | None | Dislocation mandible | | |
| M. M. | F. | 10797 | 31 | 0 | 1 min. | 10 secs. | None | Dislocation mandible | | |
| M. W. | F. | 10014 | 29 | 0 | | 55 secs. | None | Dislocation mandible | | |
| M. W. | F. | 10014 | 29 | 2 | | 55 secs. | None | Dislocation mandible | | |
| M. W. | F. | 10014 | 29 | 5 | | 55 secs. | None | Dislocation mandible | | |
| M. W. | F. | 10014 | 29 | 6 | | 55 secs. | None | Dislocation mandible | | |
| M. W. | F. | 10014 | 29 | 13 | | 55 secs. | None | Dislocation mandible | | |
| P. E. W. | M. | 26439 | 39 | 0 (insulin) | | 15 secs. | None | Fracture greater tuberosity humerus, anterior dislocation head | | |
| F. C. | M. | 30801 | 21 | 3 | | 30 secs. | None | Dislocation mandible | | |
| F. C. | M. | 30801 | 21 | 4 | 1 min. | | None | Dislocation mandible | | |
| J. S. | M. | 309779 | 35 | 0 | 2 mins. | | None | Dislocation head humerus | | |
| W. T. R. | M. | 313254 | 21 | 4 | 1 min. | | None | Dislocation head humerus | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Lawrence.. | 3 | 48 | | | | | | | | | |
| Willard..... | 11 | 30 | | | | | | | | | |
| Middletown.. | 0 | 18 | No injuries | | | | | | | | |
| Pilgrim..... | 0 | 53 | No injuries | | | | | | | | |
| Rochester.... | 0 | 67 | No injuries | | | | | | | | |
| Syracuse Psychopathic | 0 | 0 | (no treatment given) | | | | | | | | |
| Utica..... | 0 | 38 | No injuries | | | | | | | | |
| Totals..... | 687 | 1,404 | 46 | 26 | 29 yrs. | 33 | 24 | 1 min. | 83.76% | 13 | 120 |

| | Metrazol | Insulin | Male | Female | Average Age | Largest Number of Convulsions Previous to Injury | Number of Cases Injured During Initial Convulsion | Average Duration of Convulsive Seizures | Percentage with No Restraint | Fractures | Dislocations |
|---|---|---|---|---|---|---|---|---|---|---|---|

insulin borderline therapy for morphine addiction." Convulsions occasionally occur, and recently psychiatrists[7] have considered them an asset in therapy.

In 1929, Nyirő and Jablonsky[8] observed that schizophrenics who also had epilepsy were apparently improved after epileptic seizures. Similar observations were made by Müller,[9] in 1930, and by Glaus,[10] in 1931. In 1934, von Meduna[11] of Budapest, conceived the idea of using convulsant drugs in schizophrenia. "The theoretical basis for the therapy is the assumption that a certain biochemical antagonism exists between the convulsive state and the schizophrenic process." He proved the impracticality of a number of the convulsant drugs and then he used 25 per cent camphor in olive oil intramuscularly. This preparation was unreliable in its effects, insoluble, toxic and painful. In 1935, he[12] employed the preparation known as cardiazol, which is marketed in this country as metrazol. Its intravenous administration produced prompt convulsive seizures without the disadvantages of the convulsant drugs which had been used previously. The drug itself is a white crystalline powder, readily soluble and bears the chemical name of pentamethylenetetrazol which has the following structure:



*Technic of Administration.*—Metrazol is prepared in 10 per cent aqueous solution, ready for intravenous use, so that 10 cc. represents 1 Gm. The dose is from 3 to 15 cc., the amount employed varying with the receptivity and sensitivity of the patient to violent convulsive seizures. The treatment is administered before breakfast with the patient in bed. The use of restraint depends upon his motor activity. With the proper nurse assistance, the metrazol solution is injected intravenously as rapidly as possible. This is necessary because the drug is excreted very quickly and because a massive therapeutic effect on the cortex is desirable.

*Description of a Typical Convulsion.*—Metrazol therapy was observed by the author in 43 males and 30 females, and was administered by Dr. Charles M. Holmes at the Rockland State Hospital. A few seconds after the metrazol is injected, its effect is evidenced. The reaction pattern depends in some measure on the patient's receptivity. Convulsions may be either petit mal or grand mal in type. The latter are desired and they are pertinent to this paper. There is frequently an aura which is described in various ways by patients: Flashes of light, darting of bizarre figures, visualization of a ball of fire, a sense of compression of the chest and difficulty in respiration. Some patients are apprehensive and others frightened and complaining. There is a prompt, pungent odor to the breath which is rapidly dissipated. There may be a short cough, terror of the impending convulsion, quick closure and opening of the eyelids and a yawn. At this point, a soft gag is inserted between the teeth to prevent biting of the tongue. In a few seconds,

FIG. 1.—Case No. 867: Fracture of the neck of the femur in a female, age 30.

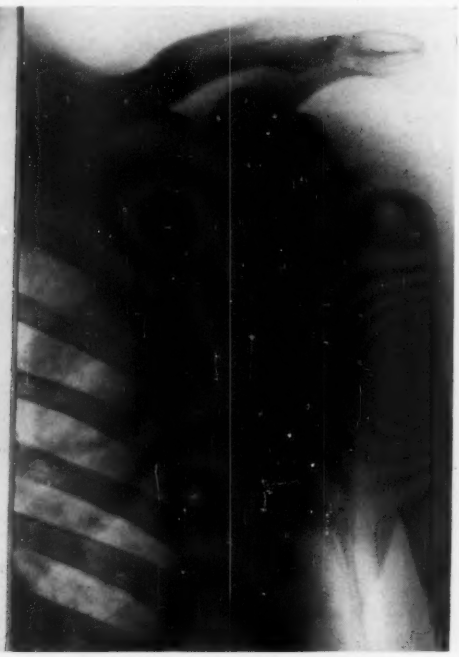


FIG. 2.—Case No. 11253: Anterior dislocation of the head of humerus in a male, age 25.

FIG. 3.—Case No. 8690: Anterior dislocation of head of humerus with fracture of greater tuberosity in a male, age 28.

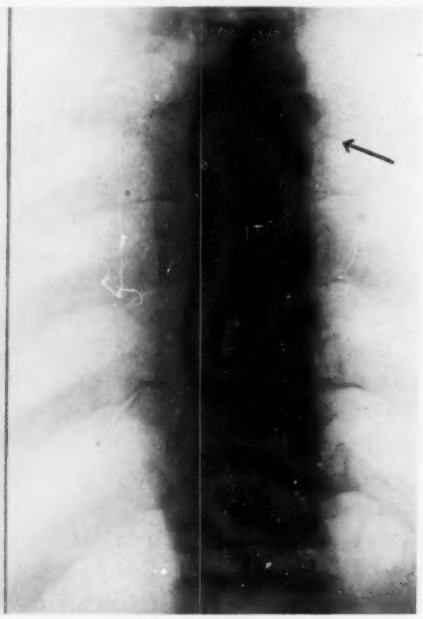


FIG. 4.—Case No. 307391: Compression fracture of the seventh thoracic vertebra in a male, age 33.

the convulsion begins with slight twitching, and very quickly it becomes clonic, tonic, or a mixture of both. The patient becomes unconscious, the eyes deviate, the pupils dilate and there is an initial pallor followed by extreme suffusion of the face. In some cases, there is a tendency for the upper extremities to be thrown upwards. As a rule, there is complete extension at the elbow and volar flexion at the wrist with bizarre flexion of the fingers and adduction of the thumb. The tonicity of the muscles is so great that the pulse cannot be felt. The lower extremities are completely extended at the knee and there is plantar flexion at the ankle joint and

FIG. 5.—Case No. 275165: Fracture of the angle of the mandible in a male, age 25.

FIG. 6.—Case No. 228552: Fracture of the anatomic neck of the humerus and the greater tuberosity with posterior dislocation of the head in a male, age 33.

occasional flexion at the hip. There may be flexion at the knee joints. Palpation of all muscles in spasm shows them to be of almost stony hardness.

The contraction of the muscles of the lower extremities is so violent that it is difficult to lift them off the bed. The muscles of the abdomen and the accessory muscles of respiration are in extreme tonic contraction. Toward the end of the convulsion there is cyanosis caused by a period of apnea from the tonicity of the muscles of respiration. In males, there may be an expression of prostatic and seminal fluid without an erection. Defecation and urination in bed are frequent occurrences.

The convulsive seizure lasts about one minute, and it is probably the most violent ever recorded in human beings. When the convulsion is over, the patient's color gradually approaches the normal. Consciousness returns quickly or slowly, quietly or accompanied by excitement. The muscles of the jaw seem the last to relax and this relaxation is sometimes not complete for about 15 minutes. The patient may fall into a slumber, the duration

of which as a rule is not more than ten minutes. This is followed by fatigue. About an hour after the therapy, he is allowed up for a bath and breakfast.

*Analysis of Statistics.*—Table II includes injuries complicating the hypoglycemic convulsions of insulin therapy. It will be noted that the total number of patients who suffered injury was 72, of whom 46 were male and 26 female. The oldest patient was 44, the youngest 17 and the average age was 29. The total number of fractures in both the insulin and metrazol therapies was 13 (0.6 per cent), and dislocations, 120 (5.7 per cent). Sixteen of these patients had recurrent dislocations of the mandible, one as many as 14. Twelve fractures (1.78 per cent) and 118 dislocations (17.2 per cent) complicated convulsions from metrazol therapy, and one fracture (0.07 per cent) and two dislocations (0.14 per cent) were produced by complicating hypoglycemic convulsions during insulin therapy. The average duration of a convulsive seizure was about one minute and the largest number of convulsions previous to injury was 33. There are recorded 24 patients injured during the initial convulsion. Eighty-three point seventy-six per cent of the patients had no restraint. The anatomic diagnoses are also designated (Table II).

TABLE II

ANALYSIS OF TABLE I

| | |
|---|---|
| Number of patients treated with metrazol | 687 |
| Number of patients treated with insulin | 1,404 |
| Number of males injured | 46 |
| Number of females injured | 26 |
| Age of oldest patient | 44 |
| Age of youngest patient | 17 |
| Average age | 29 |
| Largest number of convulsions previous to injury | 33 |
| Number of cases injured during initial convulsion | 24 |
| Average duration of convulsive seizure | 1 minute |
| Percentage with no restraint | 83.76 |

ANATOMIC DIAGNOSES

| | Totals |
|---|---|
| Dislocation mandible* | 105 |
| Dislocation head humerus | 15 |
| Intracapsular fracture neck femur | 3 |
| Intertrochanteric fracture neck femur | 2 |
| Fracture greater and lesser tuberosity humerus | 1 |
| Fracture greater tuberosity, dislocation head humerus | 2 |
| Compression fracture seventh dorsal vertebra | 1 |
| Fracture transverse processes fifth lumbar vertebra | 1 |
| Fracture neck humerus | 1 |
| Fracture anatomic neck humerus, fracture greater tuberosity, posterior dislocation head | 1 |
| Fracture angle mandible | 1 |
| Total Fractures 13—Total Dislocations | 120 |

* There were 16 patients who had recurrent dislocations of the mandible as follows: 14, 12, 7, 5, 5, 5, 4, 3, 2, 2, 2, 2, 2, 2, 2, 1. Of this number, one patient had 5 dislocations in 5 convulsions, another 7 dislocations in 7 convulsions, and 2 patients had 2 dislocations in 2 convulsions.

| | Number of Fractures | Percentage | Number of Dislocations | Percentage |
|---|---|---|---|---|
| Metrazol | 12 | 1.78 | 118 | 17.2 |
| Insulin | 1 | 0.07 | 2 | 0.14 |
| Total fractures and dislocations (metrazol) | | 130 | | 18.9 |
| Total fractures and dislocations (insulin) | | 3 | | 0.21 |
| Total fractures and dislocations (both treatments) | | 133 | | 6.36 |

TABLE III

MECHANISMS OF THE FRACTURES AND DISLOCATIONS BY MUSCULAR VIOLENCE

| Lesion | Mechanism |
|---|---|
| Intracapsular fracture neck femur | Pull of external rotators (obturator internus and externus, gluteus maximus and minimus, quadratus femoris, pyriformis and gemellus superior and inferior) and abductors of hip, mesially and cephalad (gluteus medius, pyriformis, obturator internus and externus, gemellus superior and inferior) against powerful iliofemoral ligament anteriorly |
| Intertrochanteric fracture neck femur | Pull of external rotators and abductors of hip mesially and cephalad, against pull of adductor group (adductor magnus, longus and brevis and pectineus) |
| Fracture greater and lesser tuberosity humerus | Pull of supraspinatus, infraspinatus, teres minor, and subscapularis |
| Fracture anatomic neck humerus, fracture greater tuberosity, posterior dislocation head | Forceful impaction head in glenoid fossa (for fracture anatomic neck and posterior dislocation). Pull of supraspinatus, infraspinatus and teres minor (for fracture of greater tuberosity) |
| Fracture angle mandible | Comparative weakness of angle. Pull of internal pterygoid and masseter cephalad and anteriorly. Pull of mylohyoid and digrastric caudad and anteriorly |
| Compression fracture seventh thoracic vertebra | Sudden, initial forceful flexion of thoracic portion of vertebral column by intense spasm of abdominal recti and external oblique muscles |
| Fracture transverse processes fifth lumbar vertebra | Pull of erector spinae, multifidus, intertransversalis, longissimus dorsi, psoas, quadratus lumborum |
| Dislocation head humerus and fracture greater tuberosity | Pull of supraspinatus, infraspinatus and teres minor (for fracture). Pull of pectoralis major, teres major, latissimus dorsi and subscapularis (for dislocation) |
| Dislocation mandible | Normal anterior glide condyloid process. Pull of internal pterygoid, masseter, and temporal muscles, cephalad and anteriorly |
| Anterior dislocation head humerus | Normal redundant shoulder capsule with comparative weakness antero-inferior portion, with arm in abduction. Pull of supraspinatus, infraspinatus and teres minor, posteriorly and mesially. Pull of pectoralis major, teres major, latissimus dorsi and subscapularis anteriorly and mesially |

*Mechanism of the Fractures and Dislocations.*—It is possible that a constitutional inferiority and in certain cases an osteoporosis produced by disuse, sustained posture, or prolonged undernutrition may be contributory predisposing factors to the production of injuries. It is also possible that supposedly therapeutic doses of metrazol have been too high.

The intense tonic and clonic muscle spasm produces a pathologic incoordination between antagonistic groups of muscles, which by their anatomic attachments and strong lines of pull determine the resulting lesion. It is difficult to know at which particular phase of the convulsive state the fractures and dislocations were produced. It, therefore, becomes very difficult to form a precise concept of the various mechanisms entering into the production of the complicating injuries. Brief summaries of the suggested mechanisms are given in Table III.

*Suggestions to Minimize Injuries.*—Forceful manual restraint or the use of restraining sheets should be minimized. Clearly, an additional counterforce added to an already existing pathologic force has a tendency to increase spasm and this causes a greater likelihood of injury. Pressure by a hand upward against the mandible tends to prevent its dislocation. It is a good plan to hold the upper extremities close to the trunk to prevent dislocation of the shoulder.

## SUMMARY

(1) A typical convulsion produced by metrazol therapy for schizophrenia is described.

(2) The muscle spasm is so intense that fractures and dislocations by muscular violence alone occur. By contrast, not a single injury of this type occurred in a series of 7,500 epileptic convulsions.

(3) Seventy-two patients suffered injury, of whom 46 were males and 26 females. The oldest was 44, the youngest 17, average age 29.

(4) In a series of 687 cases treated with metrazol one or more times, there occurred 12 (1.78 per cent) fractures and 118 (17.2 per cent) dislocations. In terms of the total number of convulsions (859) up to the time of injury, the fractures constituted 1.5 per cent and the dislocations 13.9 per cent, respectively.

(5) In a series of 1,404 cases treated with insulin, there were one (0.07 per cent) fracture and two (0.14 per cent) dislocations as a result of complicating hypoglycemic convulsions.

(6) All the injuries included five fractures of the neck of the femur, one fracture of the greater and lesser tuberosity of the humerus, one fracture of the anatomic neck of the humerus and greater tuberosity with posterior dislocation of the head, one fracture of the angle of the mandible, one compression fracture of the seventh thoracic vertebra, one fracture of the transverse processes of the fifth lumbar vertebra, two dislocations of the head of the humerus with fracture of the greater tuberosity, 105 dislocations of the mandible, and 15 dislocations of the head of the humerus. Sixteen patients had recurrent dislocations of the mandible.

(7) One-third of the patients suffered injury during the initial convulsion. On the contrary, other patients had many convulsions previous to injury, and one of them had 33.

(8) The mechanism of the production of the various fractures and dislocations is suggested, together with possible predisposing factors.

(9) Suggestions to minimize injuries are made.

(10) The injuries must be seriously considered in electing to employ metrazol therapy.

Since the writing of this article, there have been three additional cases of fracture of the neck of the femur at the Rockland State Hospital from convulsions produced by metrazol therapy. At the Psychiatric Institute 20 males and 31 females had 529 convulsions as a result of the therapy. Compression fractures of bodies of vertebrae were demonstrated by roentgenogram in a total of 22 (43.1 per cent) of the 51 patients and they included six males (30 per cent) and 16 females (51.6 per cent). All the fractures were found in the thoracic vertebrae, most commonly in the midthoracic region. The number of segments affected varied from one to eight, and the average was between three and four.

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# THE USE OF VITALLIUM AS A MATERIAL FOR INTERNAL FIXATION OF FRACTURES*

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ANY discussion of the methods of internal fixation of fractures, necessarily, brings up the whole question of the advisability of treating fractures by open reduction. There is much to be said on both sides. A satisfactory functional result, rather than dramatic roentgenograms, is the prime object in the treatment of every fracture, and the simplest and safest method of obtaining this result is the one to be employed. The majority of fractures can be reduced by manual force and the position of the fragments maintained by external immobilization and traction.

In certain types of fractures, on the other hand, experience has shown that open reduction and some means of internal fixation is the only procedure which offers the patient a reasonable expectation of satisfactory function. The wholesale adoption, by the inexperienced, of the first steel plates used for the internal fixation of fractures was followed by such a deluge of disastrous results that the method, in general, fell into disrepute. This unfortunate situation, however, has led to certain developments in bone surgery which now permit a more aggressive attitude toward those fractures in which serious impairment of function appears inevitable by treatment with conservative measures. The introduction by Doctor Venable of vitallium, an alloy which is practically inert in the tissues, as a means of internal fixation, has been one of the outstanding contributions to our advance in bone surgery.

Vitallium is a nonferrous alloy, being composed of cobalt, chromium and molybdenum. Its physical and chemical properties, and its reaction when placed in living tissue, have been described in articles by Doctors Venable, Stuck and Beach. Experimental and clinical evidence indicate that vitallium is the most "silent" of all the metals or alloys employed for internal fixation of fractures. The most serious objection to other material utilized for this purpose was their electrolytic action upon the host tissue, as manifested by a local area of tissue necrosis, with absorption of the bone about the screws and plate. The consequent loosening of the screws impaired the stability of the internal fixation, and the devitalized tissue favored bacterial growth.

This article is based upon a study of 65 cases in which vitallium was employed in the form of plates or screws, or both, as a material for internal fixation of various types of fractures. The tissue response to the metal was observed for the purpose of determining the presence or absence of: (1) Cor-

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rosion of the metal with staining or devitalization of the adjacent soft tissue; (2) absorption of the bone about the screws; (3) incidence of infection in simple fresh fractures; (4) tolerance of the tissues to the vitallium in potentially infected compound fractures; and (5) the reaction of both bone and soft tissues to the vitallium in obviously infected compound fractures.

If the many disastrous results which have occurred in the past following the adoption of open reduction and internal fixation in the treatment of fractures are to be avoided, scrupulous attention to the principles of surgical asepsis must be observed. Exposure converts a simple fracture into a poten-

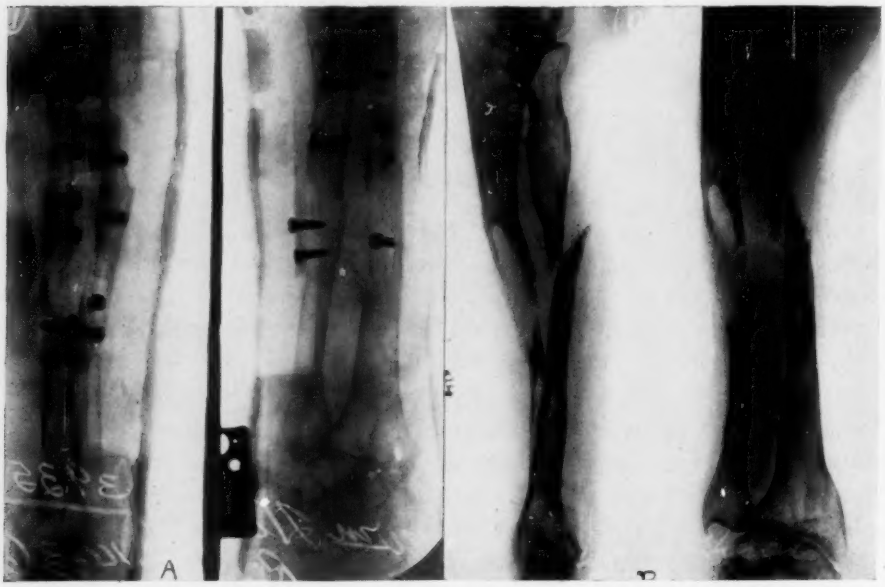

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FIG. 1.—(A) Simple fracture of both bones of the forearm, treated elsewhere by open reduction and wiring; subsequent nonunion treated by sliding bone graft operation with fixation by steel screws. When first seen by the author, patient had active infection in the operative wound; there was absorption of bone about the screws, and the grafts had sequestrated. (B) Same fracture, showing condition following removal of sequestra. Resulting scars, the soft tissue infection, and bony defects prevented any reconstructive surgery indefinitely. This surgical disaster may accompany any open reduction of fractures.

tially compound fracture, with all of its attendant risks. Under proper conditions, these risks are not serious and are far outweighed by the advantages of accurate replacement of the fragments and secure fixation.

*Skin Preparation and Protection.*—The practice of shaving and cleansing the skin on the operating table immediately prior to operation is to be avoided whenever possible. Rather, a preliminary preparation, consisting of shaving and thorough washing with soap and water, followed by the application of benzine, ether, and the routine skin antiseptics, and a sterile dressing should be made 12 hours before operation. A second routine preparation is carried out on the table. During operation, contact with the skin is avoided by

enclosure of the member in sterile stockinette fastened to the skin edges of the wound.

Operation should never be undertaken immediately after removal of a plaster encasement. The region which has been enclosed in the encasement is covered with partially desquamated skin which cannot be removed during the ordinary surgical preparation. A period of at least four days should be allowed for adequate cleansing of the skin.

A routine method of draping the extremities, which provides protection against contamination of the hands during the draping and of the operative field during movement of the extremity incident to reduction of the fracture, should be mastered by the entire surgical team. This admonition perhaps seems unnecessary, but the authors have observed that, in many hospitals, in which the majority of the surgery is abdominal, both the operative field and the hands of the surgeons are often contaminated during the draping of an extremity, before the operation is begun. Again, unsterile fields are frequently exposed at operation by the movement of the extremity necessary in the procedure.

Instrumental technic has many advantages and should be employed when possible, but is impracticable unless the entire operating team works together routinely and is trained in the details of technic. The chief advantage of instrumental technic is the avoidance of gross tears or small puncture openings in the gloves of the surgeon, through which perspiration may escape into the wound.

### USE OF VITALLIUM IN ACUTE FRACTURES

Acute fractures in which internal fixation is indicated may be divided into two groups:

(1) Fractures of Necessity: This group includes those types of fractures in which experience has shown that satisfactory position of the fragments cannot be secured or maintained by manual force or skeletal traction, and those in which treatment by these methods has failed to achieve an alignment of the fragments adequate to prevent serious disability or deformity.

(2) Fractures of Election: In this group, although sufficient anatomic position has been or can be obtained by closed reduction to afford a good functional result, the degree of displacement warrants the expectation of some deformity, a slow union, and a slight permanent disturbance in function. Formerly, this condition would have been preferable to the risks attendant upon open reduction and plating. The negligible danger incident to internal fixation with vitallium and the probability of obtaining a better functional result with a shorter period of disability, justifies a more aggressive attitude toward this type of fracture.

There is a third group of acute fractures in which the question arises as to whether internal fixation or skeletal traction should be employed. The

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FIG. 2.—(A) Comminuted oblique fracture of the tibia and fibula. Roentgenogram made after closed reduction and application of plaster encasement shows satisfactory reduction. (B) Roentgenogram made through encasement showing displacement of fragments, sufficient to delay union and impair function slightly. (C) Same fracture two months after open reduction and internal fixation with vitallium plate; solid bony union with restoration of normal anatomic position. This is a borderline case in which deformity would have been accepted before present methods of open reduction and plating were adopted.

choice here will depend upon the experience of the operator, the surgical facilities available, the general condition of the patient, and the local condition. Skeletal traction obviates the danger of wound infection and involves less surgery, but does not insure anatomic precision in the restoration of the position of the fragments. Further, longer periods of immobilization and hospitalization are required for skeletal traction. In the presence of infected skin lacerations or "brush burns" adjacent to the operative field, however, there is danger of operative infection, and accuracy of reduction should be sacrificed in favor of the safer method of skeletal traction.

Vitallium has been employed routinely by the authors as a material for internal fixation only during the past year. Twenty-two acute simple fractures have been plated, and from a clinical standpoint the method has, unquestionably, proved superior to anything we have employed previously. In some cases, roentgenograms have been made at intervals over a period of 10 months. There has been no evidence of absorption of the bone about the screws, nor any inflammatory changes in the soft tissues. The metal seems entirely inert and silent. In many cases, callus appears to have covered the plate partially—a feature seldom observed following the use of plates composed of ferrous alloys.

The majority of patients have no symptoms from the plates, and do not wish to have them disturbed. We have, however, removed eight plates which had remained in the tissues from four to 10 months. These did not show any evidence of corrosion or tarnishing. The screws were firmly imbedded in the bone, and had to be freed with a screwdriver. In no case, even in frankly infected compound wounds, were we able to lift the screws out with a hemostat, as is often possible when screws of ferrous alloys are used. The soft tissue about the plates was not stained, and appeared to be normal scar and fibrous tissue, similar to that formed in the healing of any surgical wound. In two cases, it was necessary to resect callus from over the plate before its withdrawal.

Complete immobilization and alignment of the fragments have been maintained in all cases with the exception of one, in which the plate broke. This plate was under considerable tension in the upper end of the femur and was, moreover, one of the earlier types manufactured, in which the alloy was rather brittle. This brittleness has since been corrected, and the plates are now sufficiently malleable to bend slightly to fit the contour of the bone and obviate the danger of breaking.

In the group of acute clean fractures, three infections have developed. Violation of the rules which govern operation was directly responsible for the infection in two of the three cases. In one, the operation was performed immediately after removal of a plaster encasement which had been worn for several weeks. Proper skin preparation was impossible. In the second case, there were "brush burns" adjacent to the operative site. Both of these infections could have been avoided by proper selection and preparation of the cases.

Union has taken place in all of the acute fractures. Even in the three cases in which infection developed, the fragments eventually united in satisfactory position. In the infected cases, it was necessary to remove the plates before all drainage ceased.

USE OF VITALLIUM FOR DELAYED UNION OR MALUNION OF FRACTURES

Vitallium plates have been applied to 12 fractures in which union was delayed and the fragments were in malposition, or following osteotomies for malunited fractures. In delayed union with malposition, freshening of the

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FIG. 3.—(A) Malunion of both bones of the forearm. The ends of the fragments are sclerotic, and the bone is of poor quality for callus production. In this type of case a bone graft is preferable to plating. (B) Vitallium plate was applied to radius. Union was not solid after five months; union in both fractures solid ten months postoperatively. Fracture of radius united before that of the ulna.

ends of the fragments, realignment, and secure fixation by means of a vitallium plate are usually sufficient to insure union. Fixation by the plate prevents recurrence of the displacement, which is not unlikely when union is delayed. Elimination of all movement between the fragments promotes earlier union.

In several fractures of both bones of the forearm, where one bone was plated and the other merely freshened and realigned, solid union took place in the plated earlier than in the unplated bone.

Vitallium plates are indicated as a means of fixation in malunited fractures after correction of the deformity, provided the quality of the bone is good and normal callus production may be anticipated. If the ends of the bone are sclerotic and of poor quality, and callus production will probably be slow or inadequate, an autogenous bone graft is preferable, since it affords not only mechanical fixation, but also a stimulus to osteogenesis, which is necessary in this type. Convincing evidence of this fact has been observed in three cases

of malunion in which osteotomies were carried out and vitallium plates were applied for fixation. The bone was somewhat sclerotic in all these cases and union was delayed over a long period of time, being questionable at the end of seven months in one case and after 10 months in another. In one or two other cases definite roentgenographic demonstration of solid bony union was not present for many months. Although union ultimately became solid in all these fractures, the period of disability would no doubt have been shortened and union made more certain by the use of a bone graft.

There were no infections in this group, and the roentgenograms revealed

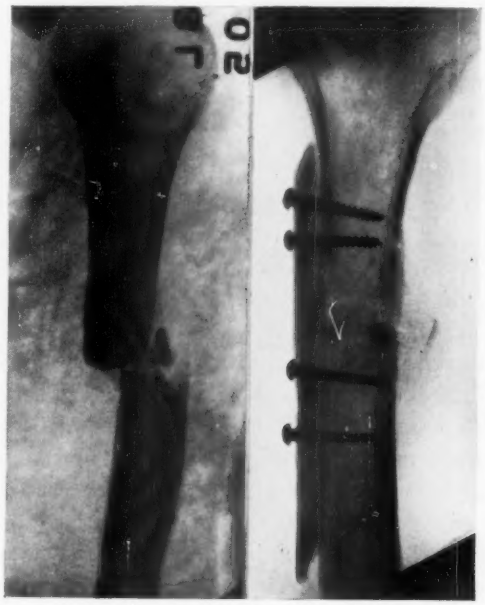

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FIG. 4.—(A) Nonunion of fracture of the humerus of four months' duration. (B) Roentgenogram three and one-half months postoperatively shows solid union after fixation by onlay bone graft and four vitallium screws.

no absorption about the screws. Thus far, the plates have not been removed in any of these cases.

### USE OF VITALLIUM IN UNUNITED FRACTURES

Surgical procedures to induce bony union in typical ununited fractures must fulfill two fundamental requirements to insure the highest percentage of successful results: (1) Accurate reduction, and adequate fixation to prevent motion between the fragments; (2) stimulation of osteogenesis.

In many ununited fractures the ends of the fragments are sclerotic, the blood supply poor, and there are other conditions unfavorable for the reformation of callus. Every possible stimulus to the formation of new bone should

be provided. For these reasons, it is felt that the use of vitallium plates should not be extended to replace bone grafts in typical nonunion. Although removal of intervening scar tissue, freshening of the ends of the fragments, accurate reduction, and complete fixation by metal plates will induce bony union in many cases, this method is less likely to be successful than fixation by bone grafts.

Solid bony union has been obtained in 93 per cent of our series of over 400 bone grafts for nonunion of fractures. We have not applied vitallium plates in typical ununited fractures, but have used vitallium screws, either alone or in combination with autogenous bone nails, as a means of fixation of these bone grafts. The use of vitallium screws simplifies the operative procedure and provides firmer fixation for the grafts than autogenous bone nails. In none of the 19 cases in which screws have been used, have any deleterious effects been observed.

### USE OF VITALLIUM IN ACUTE COMPOUND FRACTURES

Sherman and others have employed metallic plates in the treatment of compound fractures for many years, and have reported excellent results. Following the use of ferrous alloy plates, the majority of surgeons have found the incidence of infection with loosening of the screws and loss of position resulting from instability of the plate relatively high. For this reason, foreign materials for internal fixation in compound fractures have been utilized with some hesitancy. The immediate accurate reduction and secure fixation of the bony fragments in compound fractures, however, has several advantages: First, these fractures are more easily reduced immediately following injury than at any time afterward. Second, accurate reduction unquestionably hastens union. Obliteration of dead space and pockets about the ends of the bones diminishes the likelihood of infection. Third, with internal fixation there is need for less external immobilization, thus permitting observation and treatment of the damaged soft parts without constant movement at the fracture site—a disadvantage of skeletal traction.

The clinical demonstration that vitallium plates are relatively inert in the tissues, apparently having no unfavorable influence upon the incidence of infection, and the fact that there is no absorption about the screws even in the presence of infection, has convinced us that the advantages of its use in connection with compound fractures usually outweighs any theoretical objection.

The following routine technic has been adopted for the treatment of acute compound fractures:

GROUP I.—*Acute compound fractures seen during the first 12 hours after injury, in which the fracture has been compounded from the inside or there is relatively little damage to the soft tissues:* Under general anesthesia, the skin of the extremity is thoroughly cleansed with soap and water and prepared as for any operation. All obviously devitalized tissue is removed from the wound by débridement. The wound is then cleansed mechanically by copious irriga-

tion with normal saline solution; no strong antiseptics are used in the open wound. The fracture is next exposed, reduced, and immobilized with a vitallium plate and screws. The wound is partially closed, and a plaster encasement or splint applied. The administration of sulfanilamide is begun at once, as a prophylaxis against infection.

GROUP II.—*Compound fractures seen after 12 hours, or those in which there is extensive damage to the soft tissues:* In these cases, the above procedure is carried out and, in addition, incisions are made at optional points for counter drainage and the insertion of Dakin's tubes. Routine Dakin treatment is then instituted, and whatever type of external immobilization appears most suitable is applied.

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FIG. 5.—(A) Acute compound fracture. (B) Same fracture after open reduction and application of vitallium plate. Wound healed without infection. Solid bony union two months after operation.

In some cases, skeletal traction is combined with these procedures.

In fractures of the tibia and fibula or radius and ulna, in which the fracture is compound in one bone and simple in the other, open reduction and internal fixation of the simple fracture will frequently maintain alignment of both bones and obviate the necessity of operating upon the compound fracture. Fixation of the fibula in compound fractures of the tibia is a typical example of this variation from the usual operative procedure.

Eight of the fractures of our series were in GROUP I. All wounds have healed primarily, there has been no infection, and the plates are still *in situ* in every case. In the fractures of GROUP II, in which the wounds were grossly contaminated, there have been, of course, mild infections; these have been controlled with Dakin treatment. In no case has a severe, extensive

infection developed. The plates have maintained satisfactory position of the fragments, and the screws have not been loosened even in the presence of infection. In the majority of grossly infected cases, removal of the plate has been necessary before drainage ceased.

Although our group of compound fractures treated by fixation with vitallium plates is as yet too small to justify any positive conclusions, the clinical results following the above method of treatment have been so successful that we feel further experience will prove its soundness, and the morbidity and period of disability will be reduced. Further, the time of observation is too short to permit conclusions in regard to the rapidity of union as compared to that following treatment by skeletal traction. Apparently, however, the plate does not in any way interfere with the process of callus formation, and

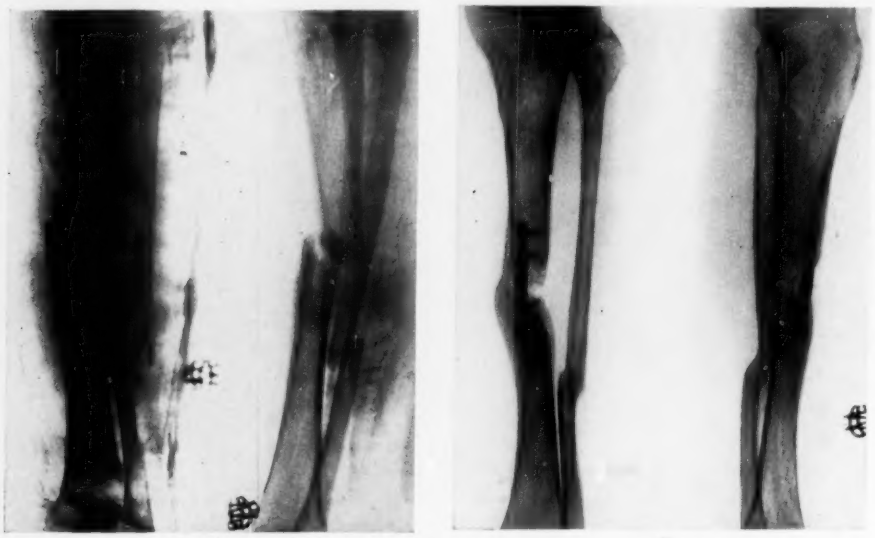

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FIG. 6.—(A) Infected compound fracture of two months' duration, treated by skeletal traction in plaster encasement; resultant malposition and nonunion. Correction impossible by manual force or traction. (B) Condition five months after correction and fixation by vitallium plate through infected field. Position is maintained; no osteomyelitis. No absorption about screws despite infection. Union practically solid.

maintenance of position with lack of movement between the fragments shortens the time required for union.

### USE OF VITALLIUM PLATES FOLLOWING CORRECTION OF DEFORMITY IN OLD INFECTED COMPOUND PRACTURES

Encouraged by the results which we have obtained in the group of acute compound fractures, we have in a few cases undertaken the correction of malpositions in old infected compound fractures with persistent drainage.

Since the operation is of necessity carried out through an infected field, sulfanilamide is given several days previously. We have been impressed with

the apparent value of this drug as a prophylactic measure in acute compound fractures and in reconstructive operations in which reactivation of an old infection appears probable.

In order to minimize the danger of sequestration of the ends of the fragments resulting from disturbance of the blood supply by the mobilization necessary to reduction, stripping of the periosteum and soft tissues from about the fragments should be restricted so far as possible. In compound fractures in malposition, nonunion is common, and union is always delayed. Gross deformity and serious disturbance in function are inevitable.

## CONCLUSIONS

Vitallium was first used in the manufacture of dentures, where resistance to infection and corroding secretions was essential. Its negligible electrolytic action, as proved by the lack of inflammation in the tissues about these plates, and the absence of absorption of bone about the screws, has made vitallium a dependable material for the fixation of fractures even in the presence of gross infection. It is not contended that the use of vitallium for internal fixation in infected compound fractures will prevent the spread of infection of the sequestration of devitalized portions of bone. Both experimental and clinical evidence, however, indicate that vitallium will aid in reducing these complications to a minimum, and that the screws will hold the plate firmly in position, preventing displacement of the bone fragments until union is firm.

DISCUSSION.—DR. CHARLES VENABLE (San Antonio, Texas): I cannot express to you how gratifying it is to see what I hoped would be true, especially as Doctor Speed and Doctor Campbell have always been opposed to hardware. I agree entirely with what Doctor Speed has to say about the selection of cases; in old ununited fractures in which the bone ends are ebonized, I think the bone graft is preferable. I feel the field is open. Indeed, we have introduced vitallium caps in cases of ankylosed hips, with gratifying success, and hope, with the experience of others gradually taking up this procedure, we may find in the course of time that we may save not only time, but may lessen the postoperative disability in arthroplasties; also that we have simplified the procedure and put it in a field that may lead to many more.

DR. EDGAR L. GILCREEST (San Francisco, Calif.): I believe that the introduction by Doctor Venable of vitallium in the treatment of fractures is epoch-making. It is the first metallic substance we have ever used for the internal fixation of fractures which is nonirritating. The toleration of vitallium by the bone and the surrounding tissues, as shown so clearly by Doctor Venable's experimental and clinical experience and by the interesting group of cases of Doctors Campbell and Speed, leaves no doubt that this metal will be used more and more. I admit that it does give the surgeon a feeling of assurance that he never had before, which could be compared to the cool confidence the Christian has who holds four aces!

It is here, however, that the danger lies, and that a note of warning should be sounded. Because it is nonirritating it will be used too often when not indicated. Always the pendulum swings too far, human nature running true to form. We should remember that the basic and fundamental principle in

the treatment of fractures does not change and that is that all fractures, if possible, should be treated immediately by a nonoperative method. In 1922, I read a paper before this Association emphasizing this point, and through the years since then I have become more convinced than ever of the soundness of this view. I hope, therefore, that the unwarranted use of this very valuable metal, for which the profession is indebted to Doctor Venable, will not bring it into disrepute which, unfortunately, so often happens.

DR. J. S. SPEED (Memphis, Tenn., in closing): I would like to emphasize again that the method of open reduction of fractures and the use of internal fixation should be undertaken with great caution, to avoid the many serious complications which accompanied the original adoption of the older Lane's plates. The operation is not a minor procedure, and should be performed under the most rigid conditions of surgical asepsis. The use of vitallium plates in connection with fresh or old compound fractures must be guided by that judgment which comes from experience in handling these cases.

# BRIEF COMMUNICATIONS

## ARTERIOVENOUS ANEURYSM OF THE NECK; UNTREATED*

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**Case Report.**—A female, age 35, presented herself at the Vanderbilt Clinic in November, 1934, complaining of a lump in the left side of the neck of nine years' duration. She had first noticed this three months after a confinement, when it grew rapidly for a few weeks. Since that time it had grown slowly. In 1931, a separate small nodule was noticed. The swelling was unaccompanied by pain or tenderness. She has four children, living and well, and has had three miscarriages. Tonsillectomy was performed in 1922, prior to which she had had tonsillitis. In 1923, she was said to have had "sprue," of which no symptoms remained. There was an abscessed tooth in 1931. Otherwise her past history was negative. She has had no upper respiratory infection or loss of weight. However, she had been in contact with her mother who died of tuberculosis.

*Physical Examination.*—There is a hard, nontender mass, 8 by 5 cm. in size, on the left side of the neck, beneath the sternocleidomastoid muscle, which is movable laterally but not vertically. A definite systolic thrill and bruit are observed over the swelling. Below this is a smaller nodule, about 1 by 2 cm. in size. The isthmus of the thyroid gland appears nodular and there is a nodule on the right. The trachea feels displaced slightly to the right. There is a bruit also over the right carotid artery. It has been noted that the bruit could be obliterated by compression of the lower part of the left common carotid artery. Except for diminished resonance over the right apex, other examination is negative. The bruit is heard as continuous—never ceasing.

*Laboratory and Roentgenologic Data.*—Wassermann negative. Hemoglobin 68 per cent. Red blood cells 4,400,000. White blood cells 8,200; polymorphonuclears 53 per cent, small lymphocytes 41 per cent, large lymphocytes 5 per cent; eosinophiles 1 per cent. The urine shows a faint trace of albumen, many pus cells, moderate epithelial cells. Roentgenologic examination of the chest shows peribronchial thickening in both upper lobes, with scattered semicalcified lesions at both apices. There is thickening of the overlying pleura. Nothing is seen which can be interpreted as fresh infiltration. A film of the cervical soft tissues shows no evidence of calcification.

This is thought to be a remarkable case of apparently nontraumatic or congenital arteriovenous communication in the left side of the neck. There are also nodules in the left side which are thought to be unrelated to the aneurysm and which are considered to be possibly tuberculous lymph nodes or lateral aberrant thyroid nodules, as the lower ones appear to be close to the thyroid gland. After compressing the left common carotid for only half a minute, the patient felt dizzy and noticed numbness in her *right* arm.

In December, 1934, aspiration over the site of the bruit on the left yielded 5 cc. of blood, intermediate in color between arterial and venous. Roentgenologic examination of the neck following "skiodan" injection showed: "Two films are of some aid in diagnosis out of a total of seven. Apparently the 'skiodan' injected into the mass in the cervical region has outlined, at least partially, an aneurysm sac, together with a tortuous vessel, lying medial to and above it, and one lying more lateral and posterior to

* Presented before the New York Surgical Society, April 13, 1938. Submitted for publication May 31, 1938.

it. These I would judge to represent the artery and the vein. It looks as though a clot may be displacing the 'skiodan' within the aneurysm." (Dr. Swenson.) A roentgenogram of the heart showed: "The measurements, at two meters, are: MR 2.3. ML 7.4 TD 9.7 GV 5.2. Internal diameter of the chest 24.0. This shows no abnormality of the cardiac contour or size. The old minimal calcified tuberculous lesions in the apices are noted." (Dr. Abbott.)

The patient was urged to practice compression on the left carotid artery daily and was sent home, to return later for operation, if found necessary after subsequent examination.

She has been seen off and on in the clinic since then. Shortly after leaving the hospital, it was found that she could stand compression for a longer period than when she left. She apparently did not practice the compression as often as we wished, due to lack of time. In January, 1935, I was impressed with the remarkable decrease in the neck swelling (*i.e.*, the aneurysm) during compression below.

In April, 1935, there had been no advance of the neck disease and the patient presented no evidence of cardiovascular damage. At that time, I felt inclined toward the diagnosis of lateral aberrant thyroid nodules with a coincident vascular anomaly in the form of an arteriovenous communication; and advised against operation for the time being. Three months later, I felt inclined to the diagnosis of lateral aberrant thyroid nodules, nontoxic nodular goiter, and congenital arteriovenous aneurysm. In November, 1935, my note reads: "No change. I am even more inclined to the diagnosis of nontoxic adenoma of left lobe of the thyroid gland, of aberrant thyroid nodules, and of congenital arteriovenous fistula."

Since then the patient has been seen every two or three months until the present time (1938). She has had several colds; sleeps poorly; and is continuously overtired; apart from which there has been no essential change in her neck or general condition since she was first seen by us in November, 1934. In view of this, operation has been postponed indefinitely.

COMMENT.—It is possible that the firm mass felt in the neck is a thrombosed or partially thrombosed (and by now probably organized) aneurysmal sac. This theory is supported by the roentgenologic study with "skiodan." During a period of three and one-half years of observation, with a total history now of twelve and one-half years of swelling in the neck, it does not appear probable that the fistula will cause harm. The nodules, however, especially if aberrant thyroid nodules, may become malignant and perhaps for this reason operative removal is advisable.

DISCUSSION.—DR. WM. DEW. ANDRUS (New York) felt that the audible murmur would certainly seem to be of the type one would expect to find in an arteriovenous aneurysm. However, it lacks one sign distinctly characteristic of abnormal arteriovenous communications of the duration of this patient's lesion; namely, dilatation of the surrounding veins. In the two cases of abnormal arteriovenous aneurysm of the neck seen by Doctor Andrus, both congenital, the dilatation of the veins of the neck was a striking feature. In this particular case, he felt that diagnosis rests between an arteriovenous communication and a simple aneurysm, possibly here associated with some clotted blood or partial clotting in the sac. Also, although distinctly more rare than the aneurysm, one must consider a carotid body tumor, very vascular in nature.

Doctor Andrus cited a case in which he performed a proximal ligation for what was felt to be a carotid aneurysm and which was characterized by

an expansile pulsation, and a murmur not nearly as loud or rough as this or quite so continuous. The patient died 10 months after operation, and at postmortem examination, was found to have a very vascular carotid body tumor. So far as the surgical attack on this case is concerned, since the mass has not enlarged in the past two or three years, one might be tempted not to operate for the time being, but Doctor Andrus felt it would probably be necessary to operate eventually. If it should prove to be an arteriovenous aneurysm, double ligation and division of the canal of communication would be the ideal procedure, but if this is not possible, quadruple ligation with excision of the fistula-bearing portion of the vessels should be attempted. In aneurysms of this region Doctor Andrus said he prefers to ligate the external carotid and put an aluminum band on the common carotid. If any evidence of cerebral anemia supervenes, the band can be removed—making the obliteration temporary.

DR. JOHN M. HANFORD (closing): In this patient, the roentgenograms showed a cavity, and when the "skiodan" was injected, there was a definite space with some dilatation, apparently. It was thought that the needle was in a vascular space because semidark blood, that looked like a mixture of arteriovenous blood, was obtained. This would seem to indicate that there was a cavity, and argue against a carotid body tumor. It is possible that the lesion is a simple aneurysm, but it does have the characteristics of an arteriovenous type of lesion.

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## ANEURYSM OF THE EXTERNAL CAROTID ARTERY WITH CAROTID SINUS REFLEX

**Case Report.**—A male, age 50, presented himself at the Vanderbilt Clinic in March, 1936, complaining of a small lump in the right side of the neck of about eight months' duration. Eighteen months prior to this, while stoking a boiler, he felt a sudden sharp pain in the right side of the neck, below the mandible, in the region of the present lump. He became dizzy and had a choking sensation, but did not collapse; he had to lie down and rest. He was conscious of a throbbing pain in the neck and temples, which gradually abated. After that time he had frequent similar episodes, which came on chiefly at night without apparent cause. He had had some precordial pain and slight dyspnea during this period. With these transitory attacks he also had dizziness, pain in the temples and right side of the neck, and flushing of the face and neck, mostly on the right side. He had not noticed that local pressure induced an attack.

His past history was essentially irrelevant. He had had attacks of malaria while on military service in India, Africa, etc. (1906–1919), and had had a bilateral ligation performed for varicose veins in 1930.

*Physical Examination.*—A generally healthy man presented a pulsating mass, about 2.5 cm. in diameter, just in front of the carotid bulb in the right side of the neck at the level of the upper border of the thyroid cartilage. The face and neck were somewhat flushed, though not markedly. Compression of the common carotid artery in the lower part of the neck obliterated the swelling and almost obliterated the pulsation. Pressure upon the mass produced no symptoms, except that it was slightly tender. The general examination revealed a slightly enlarged heart and a blood pressure of 145/90. Complete neurologic and ophthalmologic examinations were normal. The Wassermann was negative. Blood count essentially normal. Roentgenograms of the chest and neck showed no abnormality. There was a slight widening of the heart shadow. Blood urea

nitrogen, 17 mg. per 100 cc. Pulse, 72. *Preoperative Diagnosis:* Small aneurysm of the facial or external maxillary artery.

*Operation.*—April 30, 1936: Under local anesthesia, through a small, obliquely horizontal incision, the carotid bulb was exposed and a small, cylindrical dilatation of the first part of the external carotid artery found. The carotid bulb itself was normal. The cylindrical dilatation measured about 1 cm. in diameter and 2 cm. in length. A No. 1 "Deknatel" silk ligature was tied about the proximal portion of the external carotid artery, and a similar one about the origin of the superior thyroid artery, and a third one about the external carotid just above the aneurysm. The artery was not divided. Small vessels were ligated with fine black silk and the wound closed in two layers with fine silk.

*Subsequent Course.*—After a satisfactory postoperative course, the patient left the hospital on the third day, and when seen two weeks later felt "100 per cent better," and no longer felt the throbbing or the dizziness. His face was less ruddy and he had no pain.

He returned for occasional examination. In May, 1937, about one year after the operation, he felt a sense of swelling in the throat and noticed a rash over his neck, shoulders and upper chest. He again had a thorough study in the Medical Clinic, including a roentgenologic study of the chest, and a basal metabolism test. The only significant finding was a somewhat higher blood pressure. In February, 1938, 22 months following operation, the neck presented a definite prominence of the carotid bulb, which had not been present before the operation; but no symptoms developed when the bulb was pressed upon. Blood pressure, 164/100. The chief complaint was the diffuse redness of the neck and upper chest, which was passed upon by the Dermatology Clinic, with the conclusion that the redness was an erythema due to some vasomotor disturbance.

During a recent study in the Medical Clinic, Doctor Southworth suggested that this patient might have a sensitive carotid sinus reflex and, although the clinical picture is not typical of this condition, it is very possible that this case is an example of a sensitive carotid sinus reflex, induced, perhaps, by the dilatation of the external carotid artery, which acted as a local abnormal condition to produce the picture. The typical symptoms, not all present in every case, are: Transitory pallor followed by flushing of the face and neck, fainting, dizziness, convulsions, a fall in blood pressure and slowing of the heart. These symptoms, characteristically, are caused by direct pressure on the carotid sinus or bulb, but also are known to occur spontaneously.

The presumption is that the operation relieved the patient temporarily, but that he developed symptoms later, due to sensitive carotid sinus reflex associated with advancing cardiovascular disease. Since the operation, he has not had dizziness. The benefit derived from the operation may be attributed to the elimination of the aneurysm as a source of pressure, or to a partial denervation of the carotids at the bifurcation.

From a study of the researches of Weiss and his co-workers,[1, 2] the following observations have been abstracted for the purpose of adding to the interest of this clinical presentation. The carotid sinus is the same thing as the carotid bulb, or the normal dilated portion of the common carotid just at and below its bifurcation. The carotid sinus and probably also the adjacent parts of the internal and external carotid arteries are richly supplied with sensory receptors terminating in characteristic menisci. These menisci, par-

ticularly rich in the adventitia, emerge from the vessels as spiral fibers and leave the vessels as the carotid sinus nerve of Hering, or the intercarotid nerve of de Castro. This nerve (or nerves) joins the glossopharyngeal nerve and probably others, including the sympathetic. There is thus formed an afferent, direct connection with the medullary centers.

A small number of persons have a sensitive or hyperactive carotid sinus reflex. A local pathologic condition, it would appear, may induce such sensitivity, or increase the degree of sensitivity in a patient already sensitive. The response to pressure upon the sinus, generally speaking, is greater in persons with hypertension, and still greater in persons with arteriosclerosis.

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DISCUSSION.—DR. BEVERLEY C. SMITH (New York) remarked that the symptomatology of the case presented is of particular interest in view of the pathology and its site. Clinically the patient showed symptoms of an hyperactive carotid sinus reflex. The carotid sinus plexus derives afferent fibers from the ganglion nodosum of the vagus and the glossopharyngeal nerves. These terminate in sensory end-organs in the wall of the carotid bulb. Afferent fibers are derived from the superior cervical sympathetic ganglion. These are postganglionic fibers and follow the external carotid and middle meningeal arteries, innervating the meninges, and their stimulation produces meningeal and cerebral vasoconstriction and transient pain. Hering and Heymans recently established that the carotid sinus is an important secondary mechanism controlling cardiosvascular and respiratory activity. They showed that it plays a part in the regulation of blood pressure, in that, in normal arterial pressure an elevation in pressure in the carotid bulb of 10 to 20 Mm. of water produces marked fluctuation in the systemic blood pressure. Increased carotid sinus pressure causes a lowering in the systemic pressure, and with pressures above 200 Mm. of mercury, and below 50 Mm. of mercury, the reflex control and vasomotor tone disappear. The fall in the systemic blood pressure, following increase in the carotid blood pressure, was accompanied by increase in the size of the spleen and intestines, a diminished rate of blood flow and increase in cardiac volume. Perfusion of the carotid sinus with blood containing varying concentrations of $CO_2$ and other weak acids accelerated respiration. Perfusion of the isolated sinus, with adrenalin, changes the rate and force of the heart beat. Bronk (1931), using a string galvanometer attached to the sinus and a vacuum tube amplifier, showed that a burst of nerve impulses accompanied each cardiac cycle which was coincident with a rise in the carotid pressure. This action of the sinus was similar to that of the depressor cardiac nerve and tended to prevent high blood pressure or very rapid heart beat.

Weiss and Baker (1934) described a syndrome and recurrent syncopal attacks which they attributed to an overactive carotid sinus reflex. They described fainting, and convulsions from cerebral anemia following this stimulation. In their case, digital compression of the carotid bulb induced similar symptoms to those of the patient's spontaneous attacks.

The following types of reflexes from stimulation of an overactive carotid sinus have been described:

(1) Asystole or sudden pulse slowing with or without a fall in blood pressure.

(2) A fall in blood pressure, without cardiac slowing.

(3) Fainting and convulsions, without marked alteration in heart beat or blood pressure.

(4) Complete heart block, temporary ventricular asystole with auricular contraction, nodal rhythm, ventricular extrasystoles, changes in the electrocardiographic T-wave, and complete inversion of the electrical axis of the heart.

The efferent arc of this reflex, which was over the vagus, can be blocked with atropin. Novocainization or resection of the sinus nerves prevents the drop of blood pressure, fainting and convulsions following its stimulation.

Periarterial sympathectomy of the common carotid bifurcation as well as of the lower portions of the carotid arteries have relieved the symptoms of overactive sinus.

White has reported, from Massachusetts General Hospital, a group of cases with this syndrome, treated by periarterial sympathectomy, and in one of these cases, with a systemic blood pressure of 200 Mm. of mercury, digital compression of the carotid bulb produced a fall of blood pressure to 140 Mm., and a drop in pulse rate from 100 to 60. No electrocardiographic changes occurred. Sustained pressure over the carotid bulb caused deep flushing of face and pain in the arms of the compressed side, and after 20 minutes the patient lost consciousness and had a left-sided convulsion. Following novocaine injection of the carotid bulb sinus region, the symptoms could not be reproduced by the same pressure. His patient was relieved of symptoms by a periarterial sympathectomy.

The case presented is one of an aneurysm at the origin of the external carotid artery, which involved the fibers of the sympathetic nerves of the bulb region. The patient's dizziness, precordial pain, slight dyspnea, pain in his temples and right side of the neck, and flushing of his face as well as the induction of these symptoms by pressure over the carotid, have ceased since the ligation of the aneurysm.

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## MALIGNANT HEMANGIO-ENDOTHELIOMA OF THE NECK

**Case Report.**—A male, age 25, presented himself at the Vanderbilt Clinic in October, 1937, complaining of a "growth at the base of the neck." He stated that about two years prior to this he first noticed a firm, nontender lump, the size of a marble, in the right supraclavicular region of the neck and, until about three months ago, this had not troubled him in the least. At that time he was suddenly seized with a dull aching pain in the right shoulder, which radiated down his right arm. This pain persisted for about three weeks and was accentuated by motion in the shoulder joint. By this time the lump had increased in size, so he said, to approximately that of a tennis ball.

He gave a history of uncomplicated typhoid fever ten years previously; occasional sore throats, sinusitis three years ago, and hay fever for the past seven years. He had had a tonsillectomy performed 14 years previously, and a tonsil and adenoid removal two or three years before, as well as removal of a turbinate from the nose.

*Physical Examination.*—A diffuse, firm, rounded mass, about 5 cm. in diameter, was palpable in the right supraclavicular region, which was slightly elastic, slightly

fluctuant and only slightly tender. It was movable, but not freely so. The right suboccipital lymph nodes were also slightly enlarged, but not tender. There was a normal blood count, and roentgenograms of the chest and right shoulder were negative. The blood Wassermann was negative.

It was impossible to arrive at a definite diagnosis, the question of neoplasm, Hodgkin's disease and tuberculous lymphadenitis of the cervical nodes were considered.

*Operation.*—November 24, 1937: An obliquely transverse incision was made corresponding to a crease in the neck, about 2 or 3 cm. above the clavicle and deepened through the platysma and subjacent fat and descending cutaneous branches of the cervical plexus. After reaching the tumor, it was removed by alternately sharp and blunt dissection. The vessels were ligated with fine catgut and the wound closed with fine catgut for the platysma and interrupted fine silk for the skin.

*Operative Pathology.*—The tumor was soft, but did not fluctuate. It was very vascular and had the appearance of a purplish plum on the surface, and, indeed, also on cut section. It was circumscribed, although here and there moderately adherent by fine fibrous adhesions to the surrounding structures. It lay quite deep in this region, the lower part of it lying beneath the middle of the clavicle. It was not attached to any large vein. During its removal a segment of it was cut out for frozen section. Doctor Stout reported that he felt convinced it was not tuberculosis, lymphosarcoma, or thyroid tissue. He could not tell what it was. A small lymph node attached to the tumor was removed with it. There were no other lymph nodes or masses encountered; and it was impossible to tell whether this mass was single or made up of two or three conglomerate nodes. It measured about 5x4 cm. after removal, and had a smooth surface, though grossly nodular.

*Pathologic Examination.—Microscopic:* Sections show that the tumor is made up of innumerable, small vascular spaces, most of which contain red blood cells. They are lined by large, swollen endothelial cells which in many areas reach a size of four or five times their normal dimensions. These cells are heaped up and sometimes almost fill the lumina. They also appear in places to have proliferated outside the lumina. A considerable search indicates that mitotic division must be very rare, since mitoses are not found oftener than one in 25 high power fields. At its periphery, the growth seems to be confined by a capsule. This is penetrated by blood vessels at intervals, but these vessels are lined by normal appearing endothelial cells. Accompanying the tumor and attached to one end is a lymph node which has dilated sinuses filled with red blood cells. At one point in the marginal sinus is a group of tumor vessels. This is at the end opposite the attachment of the tumor and must represent an invasion, or, more probably, a metastasis. This seemed to the pathologist to be a definitely malignant vascular tumor, the active elements of which are the endothelial cells. The question of terminology is a difficult one because of the great variety of names used for the malignant vascular tumors and the lack of accepted criteria for them. According to our classification, in this laboratory, this would be called a hemangio-endothelioma, because it is a vascular tumor in which the important malignant cells are atypical endothelial cells. *Pathologic Diagnosis:* Hemangio-endothelioma of supraclavicular region with metastasis to a supraclavicular lymph node.

The patient made an uneventful recovery, but in view of the diagnosis and the possibility of malignancy, it was advised that a lower neck dissection be performed. Accordingly, on December 27, 1937, about one month after the first operation, a lower right, radical neck dissection, according to the technic of Dr. George H. Semken, was performed.

*Pathologic Examination.—Microscopic:* Sections of two of the lymph nodes removed show that there is a rather widespread fine fibrosis with lymphoid hyperplasia and dilatation of the lymph sinuses, but no evidence of the angiomatous growth. Sections taken from different parts of the cicatrix show that there is an unusual amount of scar tissue,

which encloses many groups of foreign body giant cells, which have apparently phagocyted fragments of catgut, and are surrounded by an adult granulation tissue infiltrated with many lymphocytes and other inflammatory cells. Here, also, there is no evidence of tumor. *Pathologic Diagnosis:* Cicatrix of supraclavicular region and chronic supraclavicular lymphadenitis.

*Subsequent Course.*—The patient made an uneventful recovery from the second operation, and when seen six weeks later, the wounds had healed; a slight degree of trapezius paralysis was noted. Three months after operation, after the patient had been working for three weeks, he felt fairly well but complained of not gaining weight and of slight tenderness and numbness below the clavicle. At this time the scars were red but smooth, and the cosmetic result, excellent. The right trapezius is not paralyzed and there is no sign of neoplasm or enlarged lymph nodes.

Local, regional or distant metastases may, however, appear in this patient, so that frequent follow-up visits, with thorough physical examination, are advisable.

Dr. Arthur Purdy Stout, after a study of the subject, both from his own material and from the literature, has classified malignant tumors of the vascular structures of the extremities. This classification is applicable largely to other anatomic parts. The list is composed of the following tumors: Hemangiosarcoma, angiomyosarcoma, angio-endothelioma, malignant angioma, proliferative angiomatosis and malignant tumors of blood vessel walls.

The case herein reported appears to fall into the class of (angio) hemangio-endothelioma, presenting lawless growth of endothelial cells and involvement of a lymph node by metastasis from the tumor.

Discussion.—Dr. George T. Pack (New York): The location of an hemangio-endothelioma in the neck, as illustrated in the case cited by Doctor Hanford, is quite unusual in our experience. These rare tumors seem to occur more frequently in the lower extremities, especially in individuals who have varicosities. Doctor Ewing considers venous stasis a possible etiologic factor. Such venous stasis may lead to endothelial overgrowth, sometimes benign and papillary, within the lumen and in other instances to solid endotheliomata, capable of metastasizing to lymph nodes and viscera.

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## CAVERNOUS HEMANGIOMA OF A CERVICAL NERVE

**Case Report.**—A married woman, age 37, presented herself at the Vanderbilt Clinic in July, 1934, complaining of a lump in the neck of one year's duration, which was gradually increasing in size. There had been no inflammation, tenderness or pain. Except for general lassitude and frontal headache over a period of ten years, she gave a negative history. Her mother died of cancer and a sister of tuberculosis. She had had two normal pregnancies.

*Physical Examination.*—A poorly defined mass, approximately 3 cm. in size, was found deeply placed in the left lower cervical region. The question of lipoma, sarcoma, and cervical lymphadenitis were considered. *Laboratory Data:* Urine negative. Wassermann negative. Hemoglobin 90 per cent. White blood cells 6,000. Red blood cells 4,500,000. Polymorphonuclears 50 per cent; lymphocytes 42 per cent; basophiles 2 per cent, eosinophiles 6 per cent. Roentgenologic examination of the chest revealed some old tuberculosis in the right upper lung. *Tentative Diagnosis:* Lipoma.

*Operation.*—An ill-defined mass, about 2 by 3 cm., was exposed in the posterior

triangle of the left side of the neck just above the clavicle. It proved to be a soft vascular tumor in intimate contact with one of the cervical nerves, probably the fifth. No enlarged lymph nodes were encountered. The tumor was found lying just beneath one of the deep muscles, which was split longitudinally in order to reach it. When well isolated, a fairly good-sized nerve was discovered leading into it and away from it. Because of the fact that this nerve was probably an important component of the brachial plexus (apparently the fifth cervical nerve), it was thought unwise to attempt to remove the tumor for fear of damaging the nerve and causing a paralysis of the arm. The tumor was accordingly incised and a small portion of its interior removed for biopsy. The capsule of the tumor was then closed and the muscles sewed together over it; the skin was then closed with interrupted silk sutures after a small goiter tube drain had been placed in the recesses of the cavity.

*Pathologic Examination.—Microscopic:* Dr. A. P. Stout. Microscopic section revealed a large number of branching blood channels, many of which have thick walls. These walls are mainly fibrous, though smooth muscle fibers are irregularly encountered in them. There is some recent hemorrhage. The remaining tissue is dense fibrous connective tissue with few cells and no evidence of inflammation. The collagenous strands are jammed together. No nerves or nerve sheaths can be made out in this section. With Laidlaw's silver stain the cells are silver negative and very few fine reticulin strands are present. These are wrapped around the cell-containing spaces. Large pinkish, close-packed fibrous strands are predominant throughout the tissue. *Pathologic Diagnosis:* Venous racemose aneurysm (?) of the fifth cervical nerve.

Pathologist's Discussion.—"We are somewhat at a loss to interpret these findings. Apparently the lesion is essentially a vascular one and the vessels concerned in it are of the nature of veins or venous spaces which probably communicate one with the other. They are all atypical in appearance and are bound together with dense fibrous tissue so that they do not have definite, recognizable walls. I do not believe that it is a simple telangiectasis because of this bizarre appearance. I believe that the lesion is entirely benign."

*Final Diagnosis:* Venous cavernous hemangioma.

*Subsequent Course.*—The patient made an uneventful recovery, and when seen three months later still had a lump in the neck, but no symptoms otherwise. It was thought that the tumor might respond to some kind of radiotherapy. The patient has been seen occasionally since. She seems to have had no further neck trouble, her chief complaints being continuation of the frontal headaches, general malaise and coldness in the extremities. A basal metabolic study made in December, 1935, gave a −10 rate. Menopause symptoms may explain the picture.

In March, 1938, a small nodular tumor, about 2 cm. in diameter, was discovered in the right breast. Although believed to be benign, it was recommended that the tumor be removed as soon as possible and a section taken to determine its pathology. This will be undertaken shortly. The mass in the neck remains apparently unchanged.

Few cases of hemangioma of nerve trunks have been reported. In 1935,[1] only eight cases had been found. Five of these were definitely cavernous hemangiomata and possibly two of the others, the descriptions being inadequate for classification.

An apparently simple hemangioma may become locally invasive and destructive and even may metastasize to distant points.

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DISCUSSION.—DR. GEORGE T. PACK (New York) said that in Doctor Hanford's patient, the presence of an hemangioma in the fifth cervical nerve may not be a coincidental inclusion. The relationship of benign and malignant vascular tumors to the central and peripheral nervous system is curiously varied and interesting. Congenital hemangiomata have been seen which have the identical somatic distribution of certain spinal cord segments. He had recently excised a small, exquisitely sensitive nodule from the center of a large congenital cavernous hemangioma of the arm and hand; the nodule was found on microscopic examination to be a diffuse or unencapsulated, benign neuroma. Lymphangiomatous and hemangiomatous tumors are not infrequently coexistent with true von Recklinghausen's neurofibromatosis, and may constitute part of the cutaneous stigmata of this disease. A more specific regional relationship is illustrated in the peculiar von Hippel-Lindau's disease, an eponym for angiomatosis of the retina and cerebellum. The histologic relationship is demonstrated in the case of two rare, but well known tumors of the skin and subcutaneous tissues. The tumor of the glomus is a small bluish nodule occurring usually on the hands or feet, sometimes in the nail bed. It causes disability because of the extreme degree of pain which is constantly associated with it. The glomus is a congerie of arterioles which expands and contracts, and may have a function of regulating the flow of blood to the extremities. The glomus has an abundant sympathetic nerve supply as do other end-organs; the pain caused by the tumor is probably carried over afferent sympathetic fibers. Another tumor which is thought to originate from the neurocirculatory annex is the multiple hemorrhagic sarcoma of Kaposi. These tumors, which are often quite tender, vary greatly in their histologic make-up, so that different nodules on the same patient may show such different structures as angioma, neurofibroma, angiosarcoma, endothelioma, fibrosarcoma, *etc.*, all variants of the tissues involved at the site of origin.

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# CHYLOUS ASCITES

## REPORT OF THREE CASES

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THE OCCURRENCE of chylous fluid in any of the body cavities is a striking phenomenon. There are two main causes for the leakage of chyle from the thoracic duct: First, trauma producing a rupture of the duct; and second, diseased lymph nodes pressing upon the duct, with resulting extravasation of chyle into the peritoneal or pleural cavities. An occasional case has been reported from thrombosis of the left subclavian vein, from syphilis, nephritis, cirrhosis of the liver and heart disease.

In 1935, Lille and Fox[1] could find only 46 cases of traumatic chylothorax in the literature, including one case of their own which recovered after daily aspirations averaging almost two liters, over a period of four weeks, during which time the patient was put on a strictly fat-free diet, with almost immediate cure.

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In 1910, Wallis and Schölberg[2] made a very extensive study of chylous ascites from the biochemical standpoint, and collected all of the published cases. The first record of milky ascitic fluid occurring in a diseased state was recorded about 250 years ago. "Previous to 1850, there were recorded 25 cases of milky peritoneal effusions," and in the 60 years following, Wallis and Schölberg were able to trace 173 cases, including three of their own. In the 27 subsequent years, from two to five articles appeared in the literature on this subject each year.

There is much confusion in the literature regarding the classification and differentiation of milky effusions. The two types usually mentioned are chylous and pseudochylous. In the opinion of the writer the majority of these cases, whether chylous or pseudochylous, are due to a greater or lesser degree of obstruction of the thoracic duct or its radicals. True, the chemical analysis of the fluids varies greatly.

Blankenhorn[3] concludes that the term pseudochylous is misleading and should be discarded. In his study of five cases of pseudochylous ascites, he has shown definitely that the milky color of the fluid is due to emulsified fat in very finely suspended particles. Experimentally, by removing the cream from dogs' chyle and then extracting a large part of the protein, he was able to produce the so-called "pseudochylous" fluid. His work confirms that of Grandin.

Of the three cases herewith reported, one was on Dr. J. W. Robinson's service and the other two were personal cases. However, it was my privilege to treat Doctor Robinson's case during his absence and to perform one of the aspirations. I am indebted to him for permission to report it.

## CASE REPORTS

**Case 1.**—Service of Dr. E. W. zur Horst. R. W., female, age 46, was admitted to Mercy Hospital, Pittsburgh, February 24, 1930, complaining of abdominal distress and fulness of four months' duration. Her past history was essentially negative except for an hysterectomy, presumably for fibroids, at age 32.

*Physical Examination.*—The abdomen was markedly distended; flat to percussion; and exhibited a fluid wave. A median operative scar extended from the symphysis pubis almost to the ensiform. Some edema of the ankles. Chest negative. Pulse, 76. Blood-pressure, 90/50.

*Operation.*—Under local anesthesia, an incision about one inch in length was made, and 16 liters of milky fluid removed by aspiration. Upon standing, this had the appearance of a mixture of 75 per cent milk and 25 per cent coffee. After aspiration, a mass of considerable size could be felt in the epigastrium and left hypochondrium. It was quite tender, moderately fixed and seemed to involve the stomach. A barium meal given three days later showed the mass to lie above and behind the stomach.

Bacteriologic and chemical analyses of the aspirated fluid showed no growth on culture. Specific gravity, 1.025. Positive reaction for fat with Sudan III. Fat content, 0.8 per cent.

On June 23, 1930, 13 liters of chylous fluid were again aspirated from the abdomen.

On September 15, 1931, the patient complained of dyspnea and abdominal fulness. Roentgenologic examination showed a left pleural effusion with displacement of the heart to the right. Four liters of chylous fluid were aspirated from the abdomen and a similar amount of straw-colored fluid removed from the left chest.

On March 6, 1933, five liters of chylous fluid were withdrawn from the abdomen. No evidence of pleural effusion was noted; there was apparently a slight pleural thickening.

On April 19, 1935, the patient was readmitted to the hospital, complaining of pain in the left scapular region and lower back of two days' duration. Temperature, 102° F.; white blood cells, 13,700, polymorphonuclear leukocytes, 83 per cent, mononuclear leukocytes, 12 per cent, lymphocytes, 5 per cent. Blood pressure, 108/72. Weight maintained at 190 pounds. A mass was present in the left hypochondrium, the size of an orange. No ascites was demonstrable. Dulness to flatness obtained over the lower third of the left chest.

On April 23, 1935, 750 cc. of heavy chocolate colored fluid were aspirated from the left chest. *Pathologic Diagnosis:* Massive hemorrhagic pleuritis with effusion. Secondary carcinoma of pleura (?). (The second diagnosis was predicated upon the finding of a few clumps of cells that were suggestive of columnar cell types.)

The patient was discharged, much relieved, April 30, 1935, but was readmitted July 14, 1937, complaining of pain in the upper abdomen of two days' duration. This was sharp in character and not related to meals. Attacks lasted one and one-half to two hours. She had lost 20 pounds during the last two years, and suffered from dyspnea and palpitation on exertion.

*Operation.*—July 16, 1937: Under local anesthesia, a short incision was made in the left upper quadrant, through which a large mass was disclosed, situated below the stomach along its greater curvature. There were numerous nodules 1 to 2 cm. in diameter on the parietal peritoneum. The abdomen contained about three liters of chylous fluid. A biopsy specimen was taken for histologic examination, the fluid aspirated and the wound closed.

*Pathologic Examination* showed the presence of an undifferentiated tumor cell, from which it was impossible to infer the location of the primary lesion. *Diagnosis:* Abdominal carcinomatosis.

Analysis of the chylous fluid showed N. P. N., 26.7 mg., uric acid, 5.9 mg., creatinin, 1.4 mg., and cholesterol, 118 mg. per 100 cc.; sp. gr., 1.018; coagulation, positive with heat and acetic acid; Rivalta test, positive; red blood cells and white blood cells present.

The patient was discharged July 24, 1937, and died September 8, 1937. No autopsy was obtained.

**Case 2.**—Courtesy of Dr. J. W. Robinson. E. M., female, age 54, was aspirated by me August 30, 1930. Ten liters of yellowish chylous fluid were withdrawn from the abdomen through a short incision. Previously, a biopsy of axillary and femoral lymph nodes showed lymphoblastoma (Hodgkin's disease), and three weeks before I operated, eight liters of chylous fluid had been aspirated by Doctor Robinson. In all, four aspirations were performed, each of eight to ten liters, at intervals of three weeks. On October 10, 1930, she was discharged, and is thought to have died within a few weeks.

**Case 3.**—Service of Dr. George Kastlin: O. S., colored, female, age 36, was admitted to Mercy Hospital June 24, 1934, with a history of having presented herself, seven weeks previously, at the Pittsburgh Skin and Cancer Foundation, complaining of abdominal distress, fulness and enlarged nodes on both sides of the neck. Because of a strongly positive Wassermann reaction, she was given 11 intravenous injections of neoarsphenamine. Treatment was discontinued because the abdomen was constantly enlarging, and there was a rapid decline in her general condition.

On July 24, 1934, eight days before admission, I performed a biopsy on the cervical lymph nodes which showed caseous tuberculosis. For 13 days following admission, up until the time of operation, the temperature rose to 102° F. each day, occasionally to 103° F.; pulse, 120. Roentgenologic examination of the chest showed no

definite evidence of tuberculosis. Blood counts were practically negative except for a mild secondary anemia. Wassermann: Lipoid negative, cholesterin four plus. Kahn four plus. The abdomen was markedly distended and evidenced the presence of fluid. There was a palpable mass of considerable size to the left of the umbilicus. *Preoperative Diagnosis:* Tuberculous peritonitis.

*Operation.*—August 6, 1934: On opening the abdomen, about four liters of chylous fluid escaped. There was an enormous mass of retroperitoneal lymph nodes extending from the diaphragm to a point below the level of the umbilicus. The intestines were free and the lacteals engorged. There were adhesions about the spleen, which was very nodular. There were small pinhead nodules over the surface of the liver, resembling miliary tubercles. A large dermoid cyst of the ovary was removed, also a tubercle from the liver and a very small specimen from the retroperitoneal mass. There was a little capillary oozing which could not be controlled by adrenalin applied locally. Unfortunately the bleeding and coagulation time had not been determined preoperatively, but there was no jaundice or other reason to suspect a blood dyscrasia.

Following operation, there was enough bleeding from the wound to saturate the dressing. The wound edges were separated but no bleeding point could be found. Packing with thromboplastin and adrenalin was of no avail. Death occurred 38 hours after operation, apparently due to hemorrhage in a debilitated subject.

*Autopsy.*—On opening the abdomen, it was found to contain a moderate amount of bloody serum and clots. The laboratory diagnosis was "early and late conglomerate and caseous tuberculosis of the lungs, liver, spleen, kidneys, fallopian tubes, and of the thoracic, cervical, mesenteric and retroperitoneal lymph nodes."

After removing the thoracic aorta, the thoracic duct was located. Small tuberculosis nodes were seen pressing upon it throughout its course and producing obstruction to methylene blue, which had been injected.

These three cases of chylous ascites are of interest in that the primary diagnosis in each was different—(1) carcinoma; (2) Hodgkin's disease; and (3) tuberculosis. The case with carcinoma was the only one that survived any length of time. It is rather remarkable that she should have lived almost eight years after the first appearance of ascites, and required only five tappings at increasing intervals—4, 15, 18 and 52 months. After the first two aspirations, when the amounts recovered were 16 and 13 liters, they never exceeded five liters and were as low as three. During the entire period she was kept fairly comfortable until within a few weeks of her death.

## CONCLUSIONS

Repeated aspirations would appear to be the logical treatment of such a condition, when the primary diagnosis in an incurable disease. In 1912, Morse[4] reported a case cured by venoperitoneal anastomosis. Such an operation should not be performed unless there is rapid reaccumulation of chyle after frequent aspirations, and then only when the primary condition producing the obstruction is a curable one.

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Annals of Surgery
July, 1939

# TRAUMATIC MYOSITIS OSSIFICANS

## REPORT OF A CASE FOLLOWING FRACTURE AT THE ELBOW

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NEW YORK, N. Y.

A GENERATION ago it was the custom in the case of a fracture to immobilize the injured limb for many weeks, even many months, to assure bony union, leaving it more or less to chance to obtain satisfactory function in the adjacent joints. The result of this practice was that in many regions, notably the wrist, shoulder and knee joints, the ultimate range of mobility was greatly restricted, and hence the usefulness of the limb was seriously compromised. Gradually there came about an appreciation that through minimal, though always adequate, immobilization and concurrent or early voluntary motion in the adjoining joint or joints, a greatly improved functional result can be obtained. During the World War, many fractures in both the upper and lower limbs were splinted by braces or pin-traction, which permitted motion in the joints. Early motion in the treatment of fractures became almost a fetich. It is, of course, a fact that under certain circumstances mobilization of a joint near a fracture may be instituted very early. For instance, in an uncomplicated Colles' fracture that is well reduced, motion in the wrist and fingers may be begun within a week of the reduction. This is particularly important in elderly individuals in whom fibrous ankylosis of the wrist and finger joints is likely to occur. Similarly in the treatment of a well reduced and thoroughly immobilized fracture at the shoulder, motion may be instituted during the second or third week.

Sir Robert Jones demonstrated that in the treatment of fractures at the elbow in children, the fragments of the lower end of the humerus can, after reduction, frequently be effectively immobilized by acute flexion of the elbow. The attitude of acute flexion has the further advantage of limiting the amount of blood extravasation in the antecubital fossa. The original dressing is left on for ten days, after which it is removed daily, gentle massage is applied, the patient is encouraged to move the elbow through whatever range is painless, and the limb is again bandaged in acute flexion. The voluntary, painless motion is gradually increased, and may become normal or nearly so at the end of six weeks.

Early motion at the elbow, or at any other joint, is contingent on the absence of complicating factors. Furthermore, early motion in a joint adjoining a recent fracture is always to be voluntary and painless and never a passive, forced or painful act. Passive manipulation of a joint is permissible only when the fracture is healed, that is, in the late stages, when there is reason to believe that there are adhesions, intra- or peri-articular, which restrict mobility. And even in the late stages the manipulation must never

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be forcible or rough, in order to avoid a severe reaction, with hemorrhage and the formation of new adhesions.

The case herewith reported exemplifies the potential harm of overenthusiastic or, more accurately, ill advised manipulation of a fractured elbow in the desire to obtain a satisfactory range of motion in a patient in whom there was an inherent tendency to ossification of the torn brachialis anticus muscle. Traumatic myositis ossificans is not common; probably few observers see more than three or four cases during an extensive surgical experience. Yet it occurs often enough, and has been described sufficiently thoroughly for us to have been acquainted with its clinical manifestations and therapeutic requirements. Traumatic myositis ossificans may occur anywhere in the body where there is a tear of a muscle or a ligament. An instance was recently observed by the writer, which occurred in the quadriceps muscle following repeated injuries in playing soccer. It is, however, most frequently found in the elbow joint following a fracture. It is difficult to explain why it occurs at the elbow more often than elsewhere, for the degree of injury is, as often as not, more extensive in fractures at other joints. Moreover, myositis ossificans occurs in only a very small per cent of the injuries in or near the elbow joint. One must, therefore, assume the existence in the particular patient of a personal idiosyncrasy, the biochemic nature of which is not understood. While, however, the pathogenesis of traumatic myositis ossificans is not yet comprehended, its treatment is well known. When once its presence is suspected and proven roentgenologically, the limb must be immediately protected from further injury or irritation. It may be sufficient, as it was in the case of traumatic myositis ossificans of the quadriceps muscle above referred to, to keep the patient in bed, interdicting all but the slightest motion in the adjacent joints; or it may be best, as in the elbow, to immobilize the limb in a rigid splint. The rest afforded by the immobilization favors the absorption of all or most of the calcific deposit, the resorption of the extravasated blood, healing of the torn muscular and ligamentous tissues, a rapid reduction of the swelling, and a return of the mobility of the elbow, except that degree resulting from the mechanical block of that portion of the calcified tissue which has become ossified. The earlier the lesion of traumatic myositis ossificans is protected, the more thoroughly and the more rapidly will the pathologic process subside. Serial roentgenograms of the lesion will show the gradual but continuous disappearance of the shadow of the calcified tissue, leaving only a spur or spicule of bone or perhaps no trace of its occurrence. Naughton Dunn,[1] in commenting on this complication of supracondylar fractures of the elbow, states: "Passive movements, always contraindicated in injuries to the elbow, will increase the formation of new bone. The essential treatment is to continue rest of the joint in the position of flexion until the bony deposit has reabsorbed or has completed its ossification."

**Case Report.**—R. G., female, age 5, was examined in October, 1936. Three months previously, July 17, 1936, she had sustained a fracture of the external condyle of the left elbow (Fig. 1). The limb was immediately immobilized in acute flexion, and after

ten days, passive motion was begun. The elbow remained greatly swollen and sensitive. The child complained of severe pain and refused to move the elbow. The family became greatly alarmed about the stiffness of the elbow joint and, fearing that the child would grow up with a stiff and useless elbow, instituted daily forcible passive movements of the elbow. During this manipulation the child screamed and begged to be left alone. The manipulation was continued persistently and ardently. The child continued to scream and became fearful of the approach or proximity of her mother or uncle who did the stretching. The child was adjudged to be nervous and not to be minded. When first seen by the writer, the child was frightfully apprehensive. The left elbow was greatly

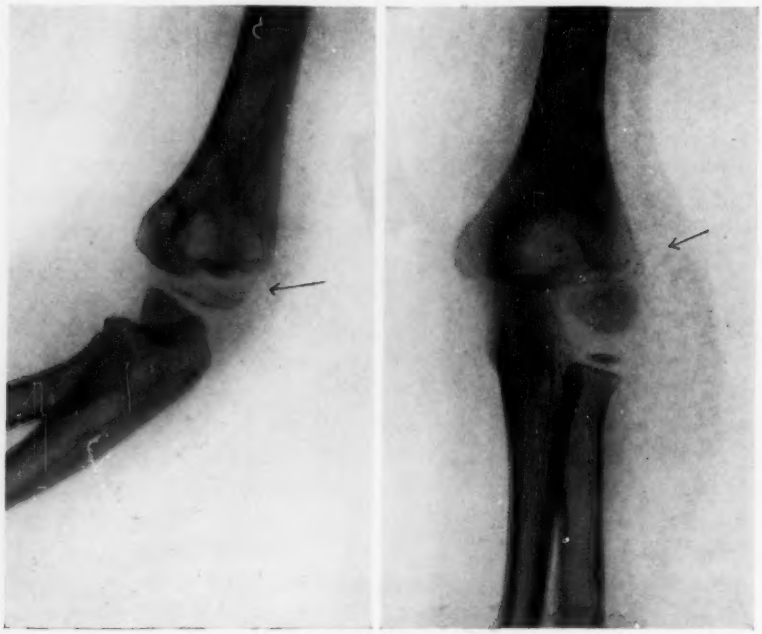

FIG. 1.—July 17, 1936: Oblique fracture of the external condyle of the left humerus. There is downward and forward displacement of the condylar fragment.

swollen and very sensitive. There was marked tenderness to pressure in the antecubital fossa and very little motion in the elbow joint. The diagnosis was readily established and rest of the elbow in a flannel sling was advised.

The patient was next seen one month later, and was not improved. The elbow was still markedly swollen and sensitive. Roentgenologic examination showed healing of the supracondylar fracture (Fig. 2 A), but, in addition, an extensive calcific deposit in the antecubital fossa in the line of the brachialis anticus muscle and the anterior surface of the capsule of the joint, extending from the shaft of the humerus, two inches above the joint line, down to the coronoid process of the ulna (Fig. 2 B.). A lateral view showed that the tear of the soft tissues involved, as it so often does, a very wide area beyond the fracture line. As happens in so many other fractures, the break in the continuity of the external condyle was a simple one, and, by far, not the most important element in the injury. Further inquiry revealed that the elbow had really not been rested. The child had been urged to move it and, in fact, manipulation, although less vigorous than previously, had been continued, the mother having an obsession about a permanently stiff elbow resulting.

The entire arm was, therefore, immobilized in a plaster of paris bandage. Three

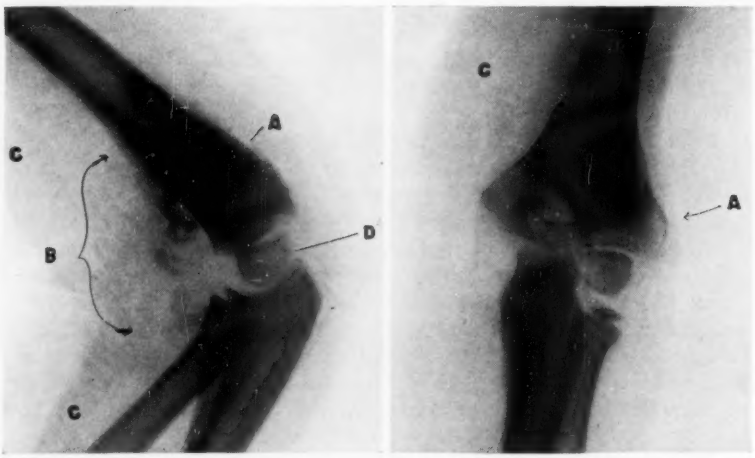


FIG. 2.—November 10, 1936: Four months after fracture. Note at (A) considerable bone formation along the posterior and lateral surfaces of the humerus. (B) Marked calcareous deposit along brachialis anticus muscle. There is marked swelling of the soft tissue (C). The capitellum (D) is displaced downward and forward.

FIG. 3.

FIG. 4.

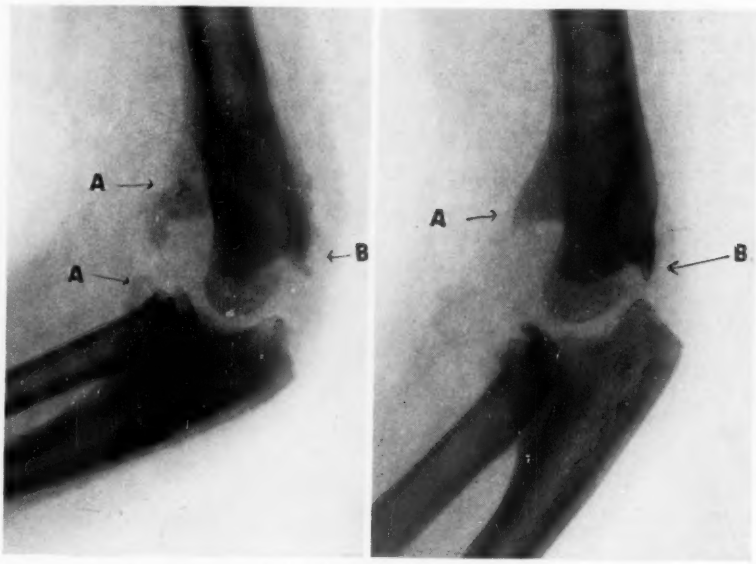


FIG. 3.—November 30, 1936 (after 20 days of plaster immobilization): Compare with Figure 2 and note the marked reduction in the swelling of the peri-articular soft tissues and in the amount of calcareous deposit (A). There is a beginning spur formation (B) on the posterior surface of the humerus.

FIG. 4.—February 25, 1937 (three and one-half months after secondary immobilization was instituted): Note the complete disappearance of the calcareous material from the antecubital fossa except for spur formation (A) on metaphysis of humerus. There is a posterior spur (B) which is likely to permanently, though only slightly, limit extension of the elbow.

weeks later the elbow was found to be of almost normal size and only slightly sensitive. There was 10° of voluntary painless motion. A roentgenogram (Fig. 3) showed a marked reduction in the soft tissue swelling and in the extent of the calcareous deposit. The elbow was again immobilized for three weeks, during which time the sensitiveness disappeared and the range of motion increased. No treatment of any kind was applied thereafter. The child, whose confidence had by this time been won, was encouraged to use the arm and move the elbow through as great a range as was possible without causing pain. By March 1, 1937, there was a voluntary range of 75° of motion, from 90° of flexion to 165° of extension, and complete pronation and supination. A lateral roentgenogram (Fig. 4) showed a spur formation at (A) on the anterior surface of the metaphysis of the humerus at the upper limit of the calcareous deposit, and complete absorption of the rest of the deposit. A bony spur was also seen on the posterior surface of the humerus (B) on the proximal side of the epiphyseal line. The anterior and posterior spurs undoubtedly accounted for the restriction in motion. But the patient already had 75° of motion in the elbow, which is a useful range even if there were to be no further increase of motion. As a matter of experience the mobility of the elbow is very likely to increase. And in any event, at a later time, if desired, either or both bony spurs might be removed by operation.

## SUMMARY

A case of traumatic myositis ossificans is reported, which occurred in a child following a fracture at the elbow. The fracture was accompanied by extensive soft tissue damage, particularly in the antecubital fossa where there occurred a thick calcareous deposit along the attachment of the brachialis anticus muscle. The efforts to obtain motion in the elbow by forcible passive movement served to perpetuate and perhaps to increase the swelling, as the enlargement of the elbow three months after the fracture was reported to be nearly as great as that noted directly after the injury. Complete rest of the elbow by immobilization of the limb in a plaster of paris bandage caused a recession of the swelling, resorption of most of the calcareous material and the return of a satisfactory range of motion in the elbow. We must, therefore, bear in mind that if, following a fracture at or near a joint, especially the elbow in children, there is persistent pain, swelling, sensitiveness and stiffness of the joint, one must suspect the deposit of calcium salts in the injured soft tissues. If the existence of this lesion, a traumatic myositis ossificans, is confirmed roentgenologically, the most effective treatment is immobilization of the limb until all the swelling and sensitiveness disappears, irrespective of the duration of the symptoms or the time it takes for them to vanish.

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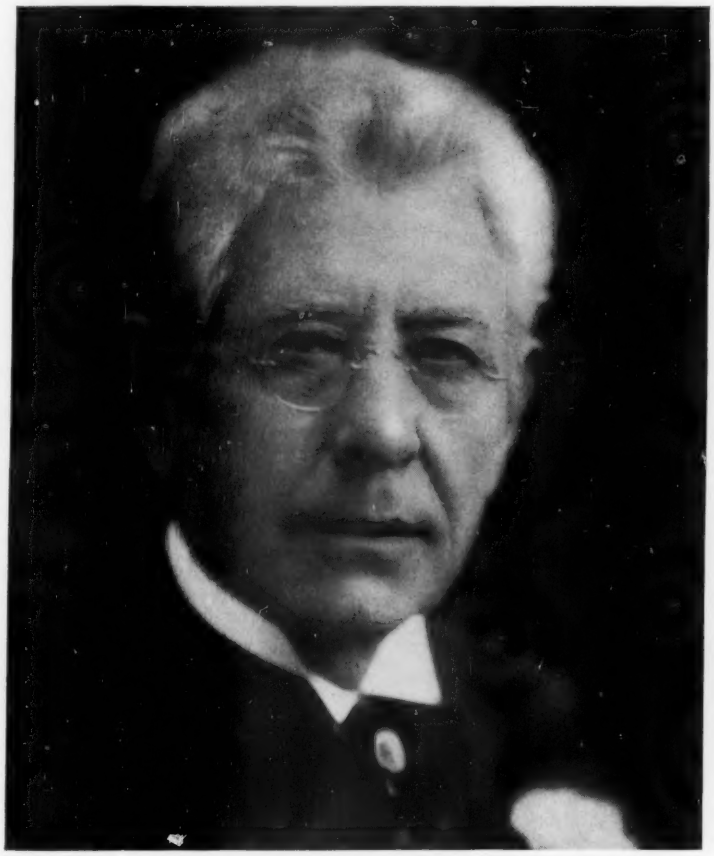
# MEMOIRS

## FRANCIS REDER

### 1864–1936

MAY 8, 1936, marked the passing of one of our most unique and lovable characters, Dr. Francis Reder. A member of our association since 1911, he was elected a senior member in 1932. Faithful in attendance and participation for many years, his genial presence will be greatly missed.



FRANCIS REDER, M.D.

Francis Reeder was born at New Athens, Illinois, January 6, 1864. His father, Dr. Franz Reder, a graduate of Heidelberg University, migrated from Germany in 1848, and Francis Reder was graduated in turn from Smith Academy and St. Louis Medical College, now Washington University Medical School, in 1884. After intern services at St. Louis City and Female Hospitals, he spent over two years with Dr. G. A. Gerster at the German Hospital in New York City, and from 1888 to 1891 in European universities and clinics.

In 1897, after several years of private practice, Doctor Reder specialized in general surgery. He was a member of the St. Louis Medical Society, which he served as President in 1932, and of the Missouri State and American Medical Associations, St. Louis Surgical Society, Southern Surgical, Southern Medical, American Association of Gynecologists and Obstetricians, and the American College of Surgeons. On November 13, 1935, he was elected an Honor Member of the St. Louis Medical Society. In 1910, he was an invited guest of the Twenty-third Congress of the Association Française de Chirurgie, in Paris.

In 1897, he married Ella Castle of Quincy, Illinois, and is survived by his widow and three children.

Honored at home and abroad, loved and respected by all who knew him, he possessed the admirable attributes of professional dignity, ability and congenial personality. To him the world was a stage, and his profession the plot, in which he labored daily, administering to the needs of his fellow men.

FRED W. BAILEY.

# JOHN ROBERTS CAULK

## 1881–1938

JOHN ROBERTS CAULK, our genial, forceful, deeply scientific, and much beloved fellow, passed away, October 13, 1938. He was born in McDaniel, Maryland, October 30, 1881, of a family established in that state by one John Caulk, who came over from Scotland with a land grant from Lord Baltimore.

Attending, successively, several Maryland schools, he received his medical degree from Johns Hopkins University, in 1906, and after serving as Assistant Physician in the Union Protestant Infirmary at Baltimore, he became Assistant Resident Surgeon and the first Resident in Urology at Johns Hopkins Hospital. He came to St. Louis, in 1910, to make his home, accompanied by his wife, Mrs. Bessie Harrison Caulk, who survives him and was ever his unfailing helpmate.

In 1910, shortly after his arrival in St. Louis, Doctor Caulk was appointed Instructor of Genito-Urinary Surgery at Washington University Medical School, and served under successive titles, including that of Professor of Clinical Genito-Urinary Surgery, which he held until his death.

St. Louis has, for a century or more, profited to an unusual extent from the professional activities of outstanding medical men who chose this center for carrying on research, and the practice and teaching of medicine. One might hazard that among these, none came better founded in his special field than Doctor Caulk, none has proved more expeditious in solving the surgical problems that confronted him, and it is likely that few had been equally blessed with the combination of pleasing manner, stimulating personality and live consciousness of his opportunities of service to the profession and the public that was characteristic of Doctor Caulk throughout his all too short working period. Public recognition came early, but it affected neither his personal balance nor the intensity of his professional pursuits. He had surgical hobbies, not everywhere accepted, and he was not without personal critics, but mostly those who knew him least.

To undertake to enumerate his original contributions to the science and art of urology, or his writings, or to name the scientific societies that claimed him as a member would for want of space defeat its own ends, but this is a tribute of friendship, not an archive, and we will turn to his more personal side.

Doctor Caulk was possessed of a most charming personality, and an air of refinement lent a delightful atmosphere to his presence. He was most entertaining and was blessed with a keen sense of wit and humor, though he could be serious minded, especially when a medical or surgical problem was under discussion. He was a very dynamic individual and was embodied with unusual energy for work. He was a great fellow to work at full speed and

play in the same manner. He was courteous and genial at all times and all his colleagues, especially those fortunate enough to have been closely associated with him, would sing his praises for his pleasant attitude at all times. He was most enthusiastic about his work and was constantly searching for new problems to solve. He was fortunate in having a multiplicity of qualifications for work and play which permitted him to do both without the sacrifice of either. His two chief hobbies were horseback riding and sailing. In the summer he loved the latter better than anything else and practically lived on his sailboat. In the spring and fall horseback riding was his most pleasant diversion. In the winter his books and extensive contributions to medical journals occupied his time at night, and the day found him laboring with unusual skill and enthusiasm on various urologic problems.

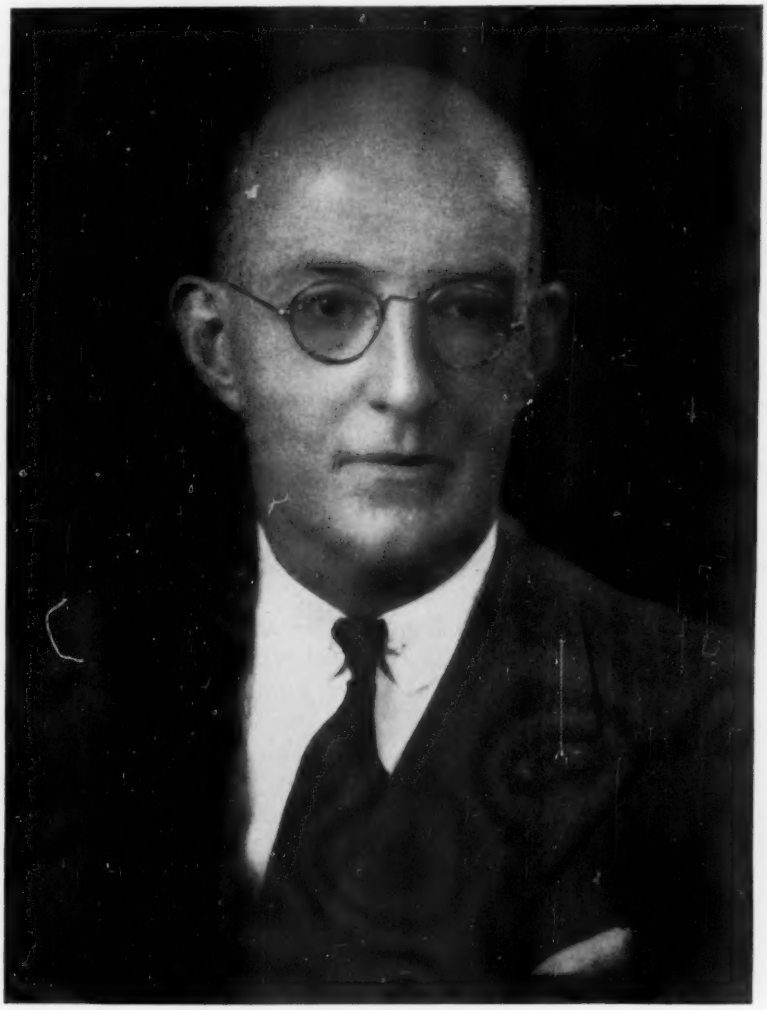
The true test of character comes through adversity even more than success. For more than a year, while in the full possession of all his mental faculties, he saw himself being eliminated from active work by a malady that proved beyond control. Toward the end he suffered almost continuously with uncontrollable pain, all of which he endured with a stoicism that any of us would envy. His personality will long be remembered by those with whom he came in contact, but the silent influence of his constructive touch in his chosen field will be active long after his personality is forgotten.

VILRAY P. BLAIR.

## JOHN HENRY NEFF, JR.

1887–1938

DR. JOHN HENRY NEFF, JR., a fellow of the Southern Surgical Association since 1926, and vice-president in 1934, was born, September 12, 1887, at Harrisonburg, Va., and died, November 8, 1938, at University, Va. He was



JOHN HENRY NEFF, JR., M.D.

the son of Dr. John Henry Neff, a practitioner in the city of his birthplace. After graduation from his local high school, he completed the classical course at the University of Virginia, where he received the A.B. degree in 1907.

Three years later he was graduated from the same institution with the degree of M.D. In 1916, he married Miss Harriet Louise Fitzgerald, of Houston, Tex., who survives him, together with two sons and a daughter.

Doctor Neff's professional life was unusual in two respects. He had perhaps the soundest background of general surgery upon which any urologist of his age has based his specialty. Seven years of house training in general surgery under Prof. Stephen H. Watts was followed by two years as Acting Associate Professor of Surgery in the University of Virginia School of Medicine. During this time he became a conspicuously competent general surgeon. In the latter portion of this period, he began to interest himself in urology and, in 1919, became Adjunct Professor, advancing through the grade of Associate Professor to that of Professor of Urology, the rank he held at the time of his death. The second unusual aspect of his career resides in the fact, reflecting his remarkable qualities of mind and character, that he was entirely a self-taught urologist. No course in urology and no trained urologic chief are responsible for his development. In spite of this lack, a possibly insurmountable handicap to lesser men, he so perfected himself as to be recognized for his professional attainments not only by a large clientele and by his local colleagues, but also by the best of his fellow urologists. Such recognition was expressed by his election to membership in the American Urological Association and in the American Association of Genito-Urinary Surgeons. Although not a prolific writer, he added from time to time sound and thoughtful contributions to the literature of his specialty. He evidenced on every occasion almost faultless surgical judgment, based upon a wide knowledge of pathology. As an operator, he was methodical, careful and thorough, respecting tissue profoundly, bold where boldness was justified. He learned transurethral prostatic resection at an age when a new and exacting technic is doubly difficult to master. His last professional paper, presented by an associate before the Virginia State Medical Association, a month before his death, dealt with his experience with this procedure and revealed how successful the new method had proven in his hands.

Doctor Neff was outstanding in the community for his kindliness, his never-failing cheerfulness, his level-headedness and his courage. Patients reacted toward him with a devotion that was almost religious in its intensity, an emotion duplicated by students and house staff alike. Without exception, his university colleagues regarded him with profound affection. They looked to him for sound judgment in difficult university and medical school matters, particularly where the ethics of a situation might not be entirely clear. When he believed that a question of ethical conduct was involved, his decisions were rapid, inflexible and always in behalf of what he considered justice and honesty. Although unyielding in such decisions, a deft removal of the sting of an opposed opinion through a mellow tact and a striking modesty, prevented antagonizing the opponent. To his acquaintances he was always considerate; and to his intimates one of the most charming of companions.

Doctor Neff, during college days, was one of the outstanding backs of the South and later a coach of college football. He was an ardent fisherman; the streams of Canada, and the tidal waters of his native state as well as local pools and brooks were the scenes of his successful sportsmanship. He was a tennis player of at least local note. When outdoor sport was impossible he found his relaxation in card playing, at which he was no negligible opponent, and in the reading of books. His literary taste was at the same time catholic and eclectic. Although professional duties prevented church attendance, he kept in touch with the activities of his denomination and contributed generously to its support. On the night before his death, he was elected to the vestry of St. Paul's Episcopal Church. In addition to the memberships in professional societies already cited, he was a Fellow of the American College of Surgeons and a member of Phi Beta Kappa, Sigma Xi and Alpha Omega Alpha.

After contemplation of his unusual record and his fine qualities of personality, one cannot wonder that the University of Virginia and the world of urology felt the untimely death of Doctor Neff as an irreparable loss. A tower of strength to all who knew him had fallen; a light that used to illuminate and cheer had gone out. The Southern Surgical Association is richer for having accorded him fellowship.

EDWIN P. LEHMAN.

## ELLIS FISCHEL

1883–1938

ELLIS FISCHEL, a product of Harvard College, and Washington University Medical School, had interned at our City Hospital and pursued postgraduate studies in Berlin, Vienna, Munich, Berne; was 29, highly trained, rugged,

ELLIS FISCHEL, M.D.

tireless, ambitious when he and I entered upon a rather lengthy professional association.

He served at some time on the staffs of ten St. Louis Hospitals; he also taught surgery at different periods in both of our local Universities, and became a member of almost every local and national society to which a surgeon is eligible.

There seem to have been three distinct and separate currents discernible in his life's work. He was, first of all, a sound surgeon with a very large

operative experience; procedures of almost unbelievable magnitude planned to cope with the regional spread of cancer were with him a matter of almost daily, successful routine. The second phase of his career, which seems to deserve special attention, is that which concerned itself with the founding and growth of the St. Louis Clinics. He was Secretary or President of this organization during its first six years, then continued as the mainspring of its existence for all the subsequent years of his life. He thereby did more, it has been said, than anyone else in our community in contributing to coordinated and publicized *postgraduate medical teaching* in St. Louis Hospitals. The third and most notable consideration which engaged most of his professional life was connected in one way or another with the study and treatment of cancer; he became successively a member of the Board of Directors of the American Society for the Control of Cancer, Chairman of its St. Louis Committee, then Chairman of its Missouri State Committee. He had been, since 1919, a member or Secretary of the Barnard Free Skin and Cancer Hospital (of our city) medical staff when, in 1933, he became a member of that institution's Board of Directors as well. He was Chairman of the Committee on Cancer of the Missouri State Medical Association for the last seven years of his life; he headed our State Cancer Commission selected by the Governor to locate, plan and construct our State Cancer Hospital which has, since his passing, deservedly been named in his honor.

His accomplishments prove that he possessed a type of imagination which enabled him to glimpse what lay beyond our common horizon; his work with the St. Louis Clinics and on the cancer problem show him to have been an exceptionally gifted executive as well.

In many instances he displayed a type of courage which goes far toward making a man seem indomitable, as when, a Harvard Senior, he won the golden bat conferred each year for the highest batting average on that rare type of player who instinctively steps forward to meet the pitch instead of drawing back from the plate as do so many others. Just as on the campus, so later, too, life's major issues were always met by him without flinching. He may be said truly to have been a stoic also, because no one ever heard him complain of blows which would have prostrated a less well poised man.

A summary of all his endeavors points unerringly toward a life of service to mankind. His efforts in behalf of the St. Louis Clinics and of the cancer cause certainly were never directed toward his own personal advancement although material reward was, of course, inescapable for a man whose attainments were far in excess of the measure to which we are accustomed.

This cultured man, finished surgeon and surpassing organizer was only 54 when devotion to his chosen field of professional endeavor led directly to his untimely end; he was hastening to Governor Stark's office for a conference regarding final details of the State Cancer Hospital design when there was a highway crash; ruthless Fate had decreed that the dream of his mature years should not become a reality for himself.

WILLARD BARTLETT.

# BOOK REVIEW

MODERN SURGICAL TECHNIC. By MAX THOREK, M.D., K.L.H. (France); K.C. (Italy). With a foreword by DONALD C. BALFOUR, M.B., M.D. (Tor.), LL.D., Complete in three volumes, with 2,147 illustrations. Philadelphia, J. B. Lippincott Co., 1938.

In spite of the fact that there are several very excellent works covering the field of General Surgery, these three volumes, devoted to modern surgical technic, furnish a wealth of information presented in a different manner than in most other text-books. For every conceivable surgical lesion there are one or more accepted surgical procedures described. These procedures have been carefully and wisely chosen so that only the best ones are included. The work is not padded with superfluous, antiquated or unusual operations which would have no value as a reference for the active surgeon. The general plan of three volumes is worthy of mention. Each volume is divided into two Parts. Each Part is preceded by a descriptive page entitled "Orientation." This gives, in brief, a general survey of the contents of the following Part. Part One consists of six chapters dealing with "The Surgeon and His Art, The Surgeon and His Patient, Postoperative Considerations, Operating Pavilions and the Operation in General, Sterilization of Surgical Instruments, and Anesthesia." These chapters constitute an introduction to the actual text which follows. A relatively large amount of space is devoted to sterilization, the arrangement and position of the operating team, the illumination of the operating rooms, the donning of gloves and gowns, descriptions of various anesthesia machines, and innumerable other details which we presume are necessary to make a work on surgical technic complete. Part Two concerns itself with the "Surgery of the Head and Neck," and a very excellent treatise on "Plastic Surgery." A good, standard operative procedure for thyroidectomy is completely described. The dangers and hazards associated with this operation are mentioned and the ever-present pitfalls are emphasized. It is noted that the only operative treatment of Ludwig's angina given, is drainage through the floor of the mouth. Nothing is said concerning a direct attack on the submaxillary nodes. This procedure has recently been reported as being very satisfactory in several cases of this distressing condition. The chapter ends with 42 pages devoted to the various types of skin grafting.

Volume Two deals with the surgery of nerves, blood vessels, bones, thorax, and breast. The more popular procedures used to-day in dealing with lesions of the nerves and blood vessels are graphically illustrated. A description of Crile's adrenal denervation for hypertension is presented. Nothing is said, however, of Crile's more recent work, namely, celiac ganglionectomy, which operation we believe has largely replaced the adrenal denervation for hypertensive cases.

Throughout the world, there is an ever increasing number of bone lesions and fractures, due to the increasing number of motor car accidents, and to

the tremendous increase in the use of industrial machinery of all sorts. This particular branch of surgery is quite properly attracting more and more attention. The so-called "Traumatic Surgeon," one who has preferably had previous general surgical training, is rapidly coming to the fore. Three hundred thirty-seven pages devoted to orthopedics, fractures, and dislocations provide a very complete guide to the proper management of these cases. The author is very conservative concerning open operations and believes that if properly handled many cases now subjected to open operation could as well be treated by closed methods.

The various standard procedures of handling breast lesions are presented. The author stresses the necessity of a radical block dissection of the nodes in the supraclavicular fossa, when these can be demonstrated to be involved. He has performed 72 such operations and was able to "cure a few cases formerly considered unoperable and abandoned to fate." The use of electrosurgery in radical mastectomy is felt to be the method of choice. Such a procedure is described in considerable detail.

The technic of pulmonary surgery is well presented. The reviewer was delighted to see that Claude Beck's work on the "Surgery of the Heart" was given proper recognition. A very complete, although concise, résumé of Beck's operations is given and very well illustrated in the closing pages of Volume Two.

The first part of the third volume concerns itself with the "Surgery of the Abdomen" and the second part with the "Pelvic Region," both male and female. Very excellent descriptions of all abdominal operations are given. The author has carefully chosen those procedures which, in his opinion, are most practical. We presume that the various operations for suspension of the stomach were inserted for historic interest and in order to make the work complete. These operations are seldom undertaken at the present time. The author favors the removal of the gallbladder by electrocoagulation and describes in detail his own operation for this condition. The subject of hernia is well presented. The newer methods of repair by fascia transplants, as well as the older methods are included in the discussion.

For resection of the rectosigmoid and rectum, the technic of Fred W. Rankin is described. The illustrations accompanying the text on this operation are by "the courtesy of Dr. Fred W. Rankin." The last 307 pages are devoted to gynecologic operations and surgery of the genito-urinary organs.

Apparently Doctor Thorek was trained in a school in which his teachers were general surgeons in the broadest sense of the word. These men were capable of removing an eye, draining a mastoid, or a brain abscess; operating upon any acute throat lesion, caring for elective orthopedic or emergent fracture cases, suturing a lacerated heart, performing any intra-abdominal surgery including gynecology and urology. Recently specialization has developed to such a degree that the so-called general surgeon is rapidly disappearing. However, there are a few left in the large metropolitan centers and a great many in the smaller cities and in the sparsely populated country districts throughout the land.

MERRILL N. FOOTE.

PHILADELPHIA ACADEMY OF SURGERY

## THE SAMUEL D. GROSS PRIZE

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THE conditions annexed by the testator are that the prize "shall be awarded every five years to the writer of the best original essay, not exceeding one hundred and fifty printed pages, octavo, in length, illustrative of some subject in Surgical Pathology or Surgical Practice founded upon original investigations, the candidates for the prize to be American citizens."

It is expressly stipulated that the competitor who receives the prize shall publish his essay in book form, and that he shall deposit one copy of the work in the Samuel D. Gross Library of the Philadelphia Academy of Surgery, and that on the title page it shall be stated that to the essay was awarded the Samuel D. Gross Prize of the Philadelphia Academy of Surgery.

The essays, which must be written by a single author in the English language, should be sent to the "Trustees of the Samuel D. Gross Prize of the Philadelphia Academy of Surgery, care of the College of Physicians, 19 S. 22d St., Philadelphia," on or before January 1, 1940.

Each essay must be typewritten, distinguished by a motto, and accompanied by a sealed envelope bearing the same motto, containing the name and address of the writer. No envelope will be opened except that which accompanies the successful essay.

The Committee will return the unsuccessful essays if reclaimed by their respective writers, or their agents, within one year.

The Committee reserves the right to make no award if the essays submitted are not considered worthy of the prize.

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Philadelphia, February 1, 1939

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